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THE ROLE OF CALCIUM IN REPRODUCTION OF THE RING-NECKED PHEASANT [1]

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Although the presence or absence of pheasants in various major areas of North America seems largely understandable, certain localized aspects of this bird's distribution have continued to puzzle wildlife biologists. In southeastern United States, summer temperatures generally are assumed to be too high to permit reproduction (Graham and Hesterberg, 1948; Bennitt and Terrill, 1940; Yeatter, 1950). Lack of water is recognized as a potent limiting factor in the West, where ringnecks are restricted to irrigated areas. In midwestern and northeastern states, however, no clear-cut relationship has been established between pheasant distribution and any ecological factor.

Pheasants are relatively abundant in southeastern Michigan but are rare in most southwestern counties of the State. Similarly, in southern Iowa, western Wisconsin, southeastern Ohio, and the cornbelt lands of Illinois and Indiana, populations of ringnecks are lower than would be expected on the basis of food and cover relationships. Ecological studies in these states have done little to explain failure in areas that appear from superficial surveys to have suitable habitat.

Leopold (1931) suggested that glaciation might in some way influence success of the pheasant in the Lake States. He believed that some factor such as lime might be supplied in glaciated areas, but did not present any experimental evidence in support of this belief. This idea was furthered by McCann (1939), who demonstrated the superiority of glacial gravel over quartz as grit, but showed that quartz supplemented with calcium carbonate was adequate.

[1] Part of the material presented here is taken from a thesis by the author submitted to the University of Maryland in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

The role of calcium was selected for study as a part of the Gamebird Ecology and Nutrition Research Project at the Patuxent Research Refuge, in 1951. The investigation was planned to include two major phases of study: an observational or field aspect and an experimental phase involving controlled conditions. Correspondingly, this report is organized under two main subheadings: "Observational" and "Experimental." Two parts of Lancaster County, Pennsylvania, similar in general appearance but differing markedly in their ability to support ringnecks, are near enough to the Refuge to permit regular field observations and study of distributional factors. The limestone valley, near Lancaster, is well known as a good pheasant area. Immediately to the south lies the non-calcareous Piedmont, almost as fertile, with a similar agricultural pattern, yet practically devoid of pheasants. It was believed that investigation of this situation might yield clues for widespread application in explaining the bird's distribution pattern.

Grateful acknowledgment is made to Durward Allen and Arnold Nelson for assistance in setting up this project, to James B. DeWitt for technical advice during the study, and to James V. Derby for making the chemical analyses.

OBSERVATIONAL

Field studies comprised a relatively minor, yet essential, part of the study. Nineteen days were spent in the two areas to ascertain the distribution of pheasants and to attempt to correlate this distribution with kind of soil, land-use factors, composition of farm crops, cover pattern, or methods of crop harvesting.

Two representative study units were selected within the limestone valley and the non-calcareous Piedmont area, respectively.

The limestone unit, henceforth designated as the New Holland area, comprises approximately 25 square miles and forms a rough triangle with the villages of New Holland, Brownstown, and Hinkletown at the apices. The other, about the same size, representing the Piedmont, lies south of the village of Quarryville, and will be called the Quarryville area.

Gross, comparative appraisal of extent of the various crops was made by driving through farming regions and measuring the roadside length of each field by car odometer. Distances were estimated to the nearest hundredth of a mile. It was assumed that roadside length of each crop would be a function of its total acreage. Inequalities caused by differences in shapes of fields tend to be offset by the large number of samples. Total figures included 74.25 miles of crop edge in the two areas (Table 1).

TABLE 1.—LAND-USE OF THE NEW HOLLAND AND QUARRYVILLE AREAS AS ESTIMATED FROM ROADSIDE SURVEYS

Type	New Holland		Quarryville	
	Miles	Percent	Miles	Percent
Corn	10.16	22.3	6.31	22.0
Wheat	6.97	15.3	4.74	16.5
Hay	9.04	19.8	5.97	20.9
Pasture	4.59	10.1	4.42	15.4
Tobacco	6.09	13.4	1.59	5.5
Buildings	4.34	9.5	1.80	6.3
Potatoes	2.28	5.0	0.69	2.4
Garden	0.80	1.8	0.35	1.2
Orchard	0.67	1.4	0.21	0.7
Oats	0.32	0.7	0.24	0.8
Beans	..	..	1.11	3.9
Tomatoes	..	..	0.36	1.3
Waste and Woods	0.34	0.7	0.86	3.0
Totals	45.60	100.0	28.65	99.9

In the New Holland area, five methods of harvesting corn were observed: (1) cutting for ensilage, (2) cutting the stalks before the ears were plucked off and later disposing of the stalks, (3) picking by machine, (4) hand-picking from standing stalks, and (5) leaving corn standing in the field. Standing corn may be harvested later by any method except the first, the corn being harvested as needed during winter or early spring.

Field observations on pheasants had as their major objective a comparison of population densities in the New Holland and Quarryville areas. An actual census was not made because of the difficulty of obtaining reliable results. Instead, the roadside count, as proposed by Bennett and Hendrickson (1938) was used with modifications. For the degree of accuracy required in the present study, it was deemed unnecessary to flush all broods seen.

RESULTS The two experimental areas agree reasonably well in percentages of basic crops (Table 1). However, there are slight deviations related to soil fertility differences of the two areas. These include the higher percentage of tobacco and potatoes in the New Holland area; also the larger percentage of buildings in this area indicate smaller farms which may reflect higher fertility. The slightly lower fertility of the Quarryville area is further indicated by the larger amount of land in pasture and waste areas.

Results of the corn harvest survey of 75 fields in the New Holland area are as follows:

Machine Picked		Cut		Hand Picked		Not Harvested	
No.	%	No.	%	No.	%	No.	%
35	46.7	31	41.3	8	10.7	1	1.3

This survey shows that a relatively small amount of winter cover is provided by standing corn in the area with the greater populations of pheasants. Since only about 20 per cent of the farmland is planted to corn, of which 12 per cent is left standing, only about 2.4 per cent of farmland had standing corn in winter. Randall (1940) found that good pheasant range in Pennsylvania was marked by about 10 per cent of the land left in standing corn in winter. His conclusion that at least 4 per cent was minimum for production of pheasants appears rather high, according to the present study.

The total number of pheasants seen in the New Holland and adjacent limestone areas on 18 field counts of approximately 20 miles each was 1,214. If standards established by Randall and Bennett (1939) for a nearby area in southeastern Pennsylvania are reliable in the Lancaster region, this count should indicate a population approaching 50 pheasants per 100 acres. In contrast, no pheasants were observed in the non-calcareous Quarryville area on eight field trips made under similar conditions, which indi-

cates an extremely low population there.

The New Holland area is heavily hunted, under game laws which restrict the kill to male pheasants. The sex ratio at the close of the hunting season probably is near 10 males to 100 females. Counts of adult birds made along roadsides in summer denoted even fewer cocks than this. For example, in July, 1951, 5 cocks, 80 hens, and 232 young pheasants were counted, providing an adult ratio of 1 cock to 16 hens. Despite the fact that cocks during summer are less readily seen than hens, there can be no doubt that the proportion of males is low in this locality. As pointed out by Dale (1951), a sex ratio as unbalanced as 1 to 10 can be expected only where there is a combination of high pheasant population and heavy hunting pressure. Areas in which pheasants are relatively scarce seldom have a sex ratio more unbalanced than 1 cock to 2 or 3 hens.

At the close of the field investigation, it was clear that the two areas were strongly similar agriculturally and also in superficial requirements for pheasant success. Only the presence of limestone appeared to differentiate pheasant habitat of the limestone valley significantly from that of the Piedmont. This theoretical factor was subjected to experimental verification at the Patuxent Research Refuge in a nutrition study from 1951 to 1953.

EXPERIMENTAL

Experimental stock each year consisted of eighty pheasants distributed into four pens. In the first year the birds were about equally divided as to sex, an unsatisfactory arrangement, since it was necessary to remove most of the cocks at the start of the mating season to control fighting. At the beginning of breeding in the first year the number of pheasants in each pen was reduced to five hens and one cock. In the second year, the experimental groups included 17 hens and 3 cocks each except in the laying season when the number was reduced to 12 hens and one cock in each pen.

Birds were from stock at the Patuxent Refuge, the parents of which had been reared on various experimental diets. There was a possibility that they might differ somewhat in vitality because of differences in carry-over of nutritional factors from the parent through the egg (Nestler, 1946). Allowance was made for this variability by distributing birds from different stocks about equally in the various groups.

Pheasants were placed in experimental pens on November 1, 1951. These pens were approximately 20′ x 50′ and were on the ground. However, because of the possibility that nutrients might be obtained from the soil, wire-floored pens were constructed and the birds were moved into them on December 20. Pine boughs were placed on the floor to provide some cover. The pens had board sides about three feet up from the floor, which cut down exposure to winds, and a panel was placed along one side from the floor to the ground in winter to reduce the force of wind that might sweep up through the wire-mesh floor. In the second year, a shelter was constructed along one side of the pens to provide protection against rain, but it was observed that the pheasants seldom went under it during rainy weather.

Experimental diets used were based on natural foods as indicated by various studies made in different parts of the pheasant's range (Cottam, 1929; Swenk, 1930; Dalke, 1937; Hiatt, 1947).

The two diets tested the first year each included corn, 65 per cent; wheat, 20 per cent; oats, 10 per cent; and alfalfa, 5 per cent. They were identical except that items for the "A" diet were from the limestone valley, while those for the "B" diet were from the Piedmont (non-calcareous) area. Materials were purchased in the two areas. They were stored at the Patuxent Research Refuge to be ground as used.

Corn and wheat, comprising 85 per cent of the diet, were purchased in relatively small lots in an attempt to obtain representative samples from the areas. Arrangements were made with two feed companies to obtain 50 pounds of wheat from each of eight lots from various farms within the two study areas. Corn was not readily available at the beginning of the experiment and consequently was purchased in small lots from time to time as needed from several localities within each of the two areas. Because amounts of oats and alfalfa to be used were small, it was believed that any differences related to source of these items would be insignificant in the total diet. Therefore, a single purchase of oats and alfalfa was made in each of the two study areas.

It was found necessary to modify this diet in mid-February to provide a source of

Vitamin B_{12}. This was done by adding 5 per cent liver meal and 2½ per cent APF concentrate which provided 3 mg Vitamin B_{12} activity per pound of concentrate. Thus the supplement added at least 165 micrograms of the vitamin per kilogram of feed.

After the results from the first year indicated that the kind of grit was more important than source of dietary materials in determining success in reproduction, the diet was still further modified. In the second year, all birds received diet "C", comprised of corn, 75 per cent; wheat, 20 per cent; and alfalfa, 5 per cent. To this was added a supplement of 4.67 per cent liver meal and 0.33 per cent Vitamin B_{12} concentrate, the concentrate adding approximately 44 micrograms of Vitamin B_{12} activity per kilogram of diet.

Crushed limestone obtained from a quarry about 1½ miles east of Hinkletown, Pennsylvania and found to be highly dolomitic was used as grit in two of the pens. It was considered to be representative of calcareous grit available to pheasants in the area. Granite grit was supplied in the other two pens. Diets were analyzed for total nitrogen, fat, crude fiber, nitrogen-free extract, calcium and phosphorus (Table 2).

Except as noted herein diets were not changed during the study, the same diet serving for winter maintenance and for breeding.

The pheasants were weighed to the nearest 5 grams about a week before the experimental diets were provided and, subsequently, were weighed at approximately 4-week intervals. Records were maintained on food and grit consumption, and notes were taken on behavior, general appearance and feathering of the birds.

During the laying period, eggs were collected at least daily and were marked as to date and pen number. They were stored in a cool place and were incubated in separate lots at about 2-week intervals. Eggs were candled at about 20 days incubation at which time infertile eggs and those that could be identified as having dead embryos were discarded. Others were transferred to another incubator for hatching.

At the end of the laying season in 1952, surviving hens were sacrificed. Tibiae were removed, fleshed and stored in ethyl alcohol for analysis. In 1953, at the beginning of the laying season, surplus hens were sacrificed and tibiae were saved for analysis with the same treatment. Both lots were analyzed for bone ash content.

RESULTS Although the outdoor pens provided approximately 50 square feet of area per bird, there was more than average feather-picking and some cannibalism among the pheasants. The tendency to stay near the periphery of the pens kept the birds close together, and it is likely that crowding contributed about as much to feather-picking as did deficiency in the diet. Despite the fact that the diets were poor, as compared with those provided for domestic poultry, the birds made good weight gains as soon as supplemental Vitamin B_{12} was supplied.

During the winter it appeared that neither type of diet nor grit was important in maintenance of the birds, since there were no significant weight differences, and all groups were alert until the onset of laying. At that time, however, it appeared that the birds on the "B" diet and with granite grit were less alert than the others. It is difficult to ascertain the time of onset of such a characteristic, yet as the laying season progressed it became evident that reactions of the different groups of birds differed. Those on the "A" diet and granite grit also began to exhibit lack of alertness, but this group did not seem to develop symptoms as rapidly as those on the "B" diet.

By mid-summer, birds receiving limestone were alert, with good plumage and held their heads high when an observer approached.

In contrast, those that received granite grit seemed unable to hold their heads erect and, at times, exhibited tremors. This con-

TABLE 2.—CHEMICAL ANALYSES (DRY WEIGHT) OF EXPERIMENTAL DIETS, A (FROM CALCAREOUS AREA), B (FROM NON-CALCAREOUS AREA), AND C (1953 DIET)

Diet	Protein Dry Basis	Ash	Fat	Fiber	N.F.E.	Ca	P.
A.....	10.75	2.33	3.91	4.37	78.64	.223	.313
B.....	10.07	2.30	3.66	4.36	79.61	.200	.431
C.....	12.33	2.24	5.13	3.08	77.22	.251	.357

dition was worst in birds receiving the "B" diet, but there was a clear distinction in the "A" diet birds between those on granite grit and those receiving limestone.

Measurement of grit consumption was difficult since the pheasants often discarded gravel picked out from the box. Despite the fact that a large sheet of metal was placed under the grit boxes, much of the waste grit undoubtedly was not recovered. Although precise measurement could not be made, much more granite was taken than limestone. For example, in one period of two weeks, consumption of limestone was estimated to be 0.46 and 0.60 grams per bird per day, respectively for the "A" and "B" diets, while granite consumption was 2.03 and 2.47 respectively. These rates of consumption are maximum, since they include grit that was wasted as well as that eaten.

Several hens died in the course of the study, and each was examined for development of eggs. All hens examined during the laying season had well-developed ova, regardless of the kind of grit they had received, yet relatively few eggs were laid by the birds supplied granite grit (Table 3). Also, there was some egg-eating by these hens. Eggs were collected several times each day, however. It is believed that not many were unaccounted for. In the second year there was less egg eating, but no more eggs were collected from the birds on granite grit than in the first year. Consequently, it was assumed that loss of eggs by eating was not a significant factor in the problem.

Hatchability was poor in all pens. This seemed, in part, to result from an unsatisfactory incubator since hatchability of pheasant eggs from other studies at the Refuge was low. Thus, although only one egg from pheasants receiving granite grit hatched in the two years, the generally low hatching success and the small number of eggs obtained from these birds reduces the statistical significance of hatchability results. Nevertheless, only one of 14 fertile eggs from birds given granite grit in the two years hatched, a success of 7.1 per cent, as compared with 48 of 173, or 27.7 of the eggs from birds supplied limestone.

Pheasants on the granite grit regimen were given a supplement of powdered calcium carbonate in the diet on April 21, 1953. These birds were in poor physical condition and by this time it was believed that the major effect of grit on egg production had been established. The response was rapid, and provided added evidence that calcium had been the deficient factor. In pen D-3, for example, only three eggs had been obtained by April 21. One of these was soft-shelled and another was imperfect. After the calcium carbonate supplement was given, apparently-normal eggs were obtained, as follows: within 24 hours, 2; the next day, 3; the third day, 4; and the fourth day, 7. By May 8, 75 eggs had been obtained from these hens.

There was no significant difference in bone ash of tibiae of birds using granite or limestone, nor of pre- and post-laying season groups. Pre-laying season averages were 57.77 per cent ash for the granite-grit group, and 58.71 per cent for those on limestone. Post-laying season averages were 59.13 for granite, and 59.53 for limestone. Both groups were lower than pheasants from other studies at the Refuge, which had an average of 64.14 per cent pre-season, and 62.90 post-season.

TABLE 3.—FERTILITY AND HATCHABILITY OF EGGS

Diet	Type Grit	Eggs Set	Number Fertile	Number Hatched	Percent Fertile	Percent Hatched
			1952			
A.....	Limestone	60	51	16	85.0	31.3
A.....	Granite	4	3	0	75.0	0
B.....	Limestone	49	26	20	53.1	76.9
B.....	Granite	6	6	0	100.0	0
			1953			
C.....	Limestone	201	96	12	47.7	12.5
C.....	Granite	17	5	1	29.4	20.0

DISCUSSION

Though the experimental diets used in this study do not conform to standards for domestic poultry (Titus, 1939), yet on the basis of food habits analyses, it appears that with the exception of some possible trace items, they are about equivalent to diets of wild pheasants.

In game-bird nutrition studies two problems are encountered which are not met in poultry nutrition research. One of these involves artificialities imposed by confinement of a wild species. As contrasted with domestic poultry, the pheasant does not react well to penned conditions. The birds are nervous and spend much time pacing around the edge of their pens. It cannot be assumed with assurance that their requirements under captivity match those of wild birds in all respects.

The second problem involves matching the natural diet. The wild pheasant fares more on a subsistence than an optimum diet. Therefore, in order to test the need for calcium in nature it is essential that the experimental diet be as nearly like the natural wild-bird diet as possible. With the exception of liver meal and Vitamin B_{12} concentrate, substituted for insects, it appears that the diets used in this experiment meet this requirement.

No attempt was made in this study to ascertain the precise role of calcium in egg production. Undoubtedly the need for a large amount of calcium in producing eggshells is basic. However, the mechanism by which lack of calcium prevents ovulation is not clear. It has been shown by Baldini and Zarrow (1952) that blood calcium level is sensitive to estrogen in the bobwhite, but evidently the relation between blood calcium level and production of the hormone causing ovulation has not been investigated. Although no test was made, it was assumed that the pheasants on granite grit were unable to build up a sufficiently high level of blood calcium to permit ovulation. This suggestion seems to offer a promising field for further study.

Egg development evidently is not dependent upon the calcium level of the diet, since birds supplied granite grit apparently had normal numbers of well-developed eggs in the ovary. This fact is also indicated by the rapidity with which increased ovulation followed the supplement of calcium carbonate in the diet.

Although the amount of calcium required for ovulation evidently is small it seems clear that the normal wild diet of the pheasant, exclusive of grit, is likely to be deficient in this element. This deficiency could be corrected either by a small amount of calcareous grit or even by ingestion of small quantities of calcareous soil. It is highly probable that the need for some calcareous supplement can explain the failure of the pheasant to become established in calcium-deficient areas within its general range. However, it does not necessarily rule out other limiting factors, such as high summer temperatures or excessive aridity.

SUMMARY AND CONCLUSIONS

The pheasant, in its North American range, seems to have had its greatest success in glaciated or in other areas associated with calcareous soils. Success has been slight in areas deficient in calcium.

In Lancaster County, Pennsylvania, no environmental difference other than presence or absence of limestone was discovered that might explain the high population in the limestone valley and the scarcity of pheasants in the non-calcareous Piedmont area.

Pheasants at the Patuxent Refuge, when given limestone grit, reproduced successfully on a diet roughly comparable to the natural pheasant diet but failed to reproduce adequately on such a diet when granite grit, instead of limestone, was supplied.

A supplement of powdered calcium carbonate in the diet was adequate to permit production of eggs by birds on the granite grit.

Birds receiving granite grit had apparently normal eggs in the ovary but failed to ovulate more than a very few eggs. The precise role of calcium in permitting ovulation was not investigated.

It is concluded that calcium, which is low in the natural pheasant diet, must be supplemented in some way to permit pheasants to reproduce. Scarcity of this element in non-calcareous areas may well explain the failure of the pheasant in many parts of North America.

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THE GROWTH RATE OF THE BLACK-TAILED DEER
(*Odocoileus hemionus columbianus*)[1]

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It is now well known that the Columbian black-tailed deer (*Odocoileus hemionus columbianus*) is represented in different environments by populations with very different ultimate body size. In searching for an explanation for this variability the influence of the nutritional environment has been suggested as one of the major sources (Cowan 1936 and Einarsen 1940). To date the evidence for this has been of an inferential nature since no precise experimental data have been published which will permit the establishment of the growth curve for this species under conditions of known nutritional status.

A further consideration in stimulating us to undertake a detailed study of certain aspects in the physiology of the larger wild ungulates was the growing conviction that the animal itself presents the most satisfactory measure of adequacy of the range upon which it has grown. The adaptability of these animals is such that species of plants ignored in one locality appear as important food items in another ecological community. Then too the complex relationship between climate, soil nutrients, ecological stage, plant community, and animal well being, is such that it seems probable that only the animal is going to offer a satisfactory assessment of life conditions on any area.

It seemed to us that an understanding of

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the behaviour of the species with regard to growth under theoretically ideal dietary conditions was an essential initial step.

In 1949, through funds provided by the National Research Council of Canada, this laboratory established a small colony of Columbian black-tailed deer. An early objective was establishment of the normal growth pattern of this sub-species as a representative of the species. The present report summarizes the first four years of observation.

The first two years provided meagre data on this aspect. It was first necessary to obtain foundation males and females which could be maintained and bred under conditions of confinement much more restrictive than is customary for work with wild ungulates. In addition manipulative and nutritional procedures had to be evolved which would permit accumulation of growth data under standard conditions.

This was necessary because we regard it essential to record normal growth only on animals of known prenatal and immediately postnatal nutritional and environmental history. For the purpose of the present study we have attempted to provide dietary conditions which would permit the animals to express their genetic growth potential. Growth is taken to mean not only increase in body mass but also in skeletal size and physiological behaviour.

EXPERIMENTAL

STOCK—All animals except No. 11 were of mainland origin. The dams weighed 120–130 lbs. and the sires at 2 years 185–210 lbs. No. 11 was by a mainland buck out of a 100-lb. Hardy Island doe. She was a first fawn, the smaller of twins of which the other died at 2 months of age.

HOUSING AND MANAGEMENT—The breeding animals have been maintained in individual pens of such form that each animal had between 50 and 60 square feet of floor area. Each pen was provided with water and a feed manger so designed that it permitted self feeding of concentrate and roughage. The pens were accommodated in an unheated barn on a concrete floor and bedded with wood shavings. The animals were bred under observation by admitting the doe to the buck's pen when she showed definite signs of oestral activity. During the second year of operations small outside exercise yards were provided. The deer were permitted use of these on one or two days a week but we now regard them as unnecessary except for breeding purposes. They have the disadvantage of complicating disease prevention and of making the control of the environmental conditions difficult.

Animals were weighed frequently, daily at first, weekly after about 3 weeks, then monthly or at longer intervals for older animals. From birth to a body weight of about 30 lbs. they were carried onto and held on the scales by a technician; beyond that weight they were halter broken and led onto a platform scale. As far as conditions permitted the animals were weighed at the same hour at each weighing.

Measurement—Since the growth in body proportions with time is of importance both from the standpoint of comparative morphology and its more direct application to wildlife management a great variety of body measurements have been taken at appropriate intervals. The recording and interpretation of these will be reported upon later.

Ration—Two concentrate rations have been used. U.B.C. ration #14 was fed from the outset until January 1952 when it was superseded by U.B.C. ration #15. The constituent composition of the two rations is given in Table 1.

TABLE 1.—CONSTITUENTS OF THE EXPERIMENTAL DEER RATIONS

	#14		#15	
	Lbs/ ton	Per cent	Lbs/ ton	Per cent
Alfalfa meal.....	460	23	460	23
Whole corn.....	560	28	620	31
Wheat bran.....	280	14	280	14
Corn gluten.....	180	9	...	..
Beet pulp.....	200	10	200	10
Molasses.....	140	7	140	7
Soyabean Meal...	140	7	140	7
Calcium carbonate	20	1	20	1
Salt (iodized).....	20	1	20	1
Copra meal.....	...	..	100	5
Calcium limestone	...	..	20	1
	2000	100	2000	100

The ingredients shown in Table 1 were mixed after grinding, then passed through a California pellet mill to produce quarter-inch cylindrical pellets. This yields a pellet having

an apparent density of 1.17 grams per cc. The proximate composition of the experimental rations and of the alfalfa hay used is given in Table 2. From time to time small

TABLE 2.—PROXIMATE COMPOSITION OF EXPERIMENTAL RATIONS AND ALFALFA HAY

	Moisture	Protein	Fat	Fibre	N.F.E.	Ash
No. 14 Pellets	10.45	16.35	3.17	8.59	53.45	8.0
No. 15 Pellets	10.4	15.4	4.0	8.4	53.6	7.7
Alfalfa Hay	11.4	12.5	1.2	37.5	30.5	6.9

quantities of browse from the following species were provided: *Alnus rubra, Gaultheria Shallon, Rubus parviflorus* and *Prunus emarginata.* This browse, while not strictly necessary was offered as a concession to the normal preference for a mixed diet. Its total contribution to the caloric intake was negligible.

The pelleted rations, along with roughage in the form of alfalfa hay, were fed *ad libitum.*

RESULTS AND DISCUSSION

We do not wish to enter the continuing polemic on the methods of expressing growth rates in animals. We prefer to use the methods of growth expression suggested by Brody (1945). His methods are used here with the full knowledge that they are not completely adequate, but their use appears justified on the grounds that they do permit a reasonable division of the growth curve into its component physiological phases. We are satisfied that the degree of refinement is adequate if considered in light of limitations of the animal material.

Following this method we have regressed age in days against the logarithm of body weight having recourse for simplicity to arithlog coordinate paper. The method of least squares was used to obtain the line of best fit over each linear portion of the growth curve. This reveals in the growth curve a series of reasonably distinct phases over which growth occurs at what might be called a constant percentage rate. It is our opinion that these apparent phases of constancy are artifacts to the extent that they represent periods of relative linearity.

TABLE 3.—REPRESENTATIVE BODY WEIGHTS IN RELATION TO AGE

Deer No.	Sex	Birthdate	Weight in lbs. at Age in days 0	3	6	9	12	15	18	21	28	35	42
1	F, t	June 7	6	7.6	9.6	11.2	12.5	13.5	15.	16.5	18.5	19.8	21
2	M, t	" 7	7.5	8.7	10	13	14	16.5	19	20.5	21	22	26
3	M, t	" 5	6.5	7.5	8.8	10.5	12	13.5	14	14.7	16.5	18.2	20.5
4	M, t	" 5	6.7	7.8	9.0	10.5	12.2	14.5	15.2	16.0	17.5	19.5	21.5
7	M, t	" 3	6.8	8.7	10.1	12.0	13.7	15.5	16	17	18.6	21	23
8	M, t	" 3	6.6	8.6	9.6	11.5	13.0	15	15.5	17.0	18.5	20.5	22.5
5	M, s	Aug. 1	7.5	8.5	9.8	11.5	13.2	15.2	17.7	20	25.5	27.5	29.5
6	M, s	June 10	8.0	10.0	10.5	13.5	14.6	15.2	16.0	16.5	18.5	20.5	22.5
1H	M, t	" 17	6.0	6.9	8.0	9.0	14.5	16.4	17.0	18.0	20.9	23.8	27.0
2H	M, t	" 17	6.0	8.5	9.2	10.0	14.5	16.0	17.3	18.1	20.2	22.7	25.0
11H	F	July 3	4.5	6.0	6.7	7.5	9.5	11.0	11.5	12	13.4	15.0	16.5

Deer No.	Sex	Birthdate	*Continued*—Weight in lbs. at Age in days 49	56	63	70	77	84	91	98	105	135
1	F, t	June 7	26	29	31	34	37	40	41.5	46.5	50	70
2	M, t	" 7	31	33	36	39	43	47	51	55	60	70
3	M, t	" 5	22.5	25	28	31	34	38	42	47	51	68
4	M, t	" 5	24.0	27	29.7	33	36	40	44	48.5	54	70
7	M, t	" 3	25.5	28.2	32	35	39	43	52	52	54	60
8	M, t	" 3	25.0	27.0	30	33	36	40	42	49	52	58
5	M, s	Aug. 1	31.7	34	37	39	42	46	49	52.5	55	63
6	M, s	June 10	25.0	27.5	31	34	37	42	46	48	50	60
1H	M, t	" 17	30.8	33.8	36	37.8	40	42.1	44.4	47.1	50	63.5
2H	M, t	" 17	28.0	30.9	35	38.2	42.1	44	46.3	48.9	51.3	61.5
11H	F	July 3	18.7	21	28.2	25	26.5	28	..	..	..	..

On the basis of such regression lines it has been found that there is a remarkable constancy about the manner in which the blacktailed deer grows during the first six months, at least, of its life. Table 3 presents the actual body changes with time of 10 representative animals, additional data are on hand and will be included in the final paper. Figure 1 illustrates the nature of the growth curve of a single fawn (No. 6) and twin fawns (Nos. 7 and 8).

Under our conditions the mean weight at birth has been 6.76 lbs. (6.0–8.0) (one exception), which represents approximately 5 per cent of the body weight of the non-pregnant doe. Corresponding data on other wild ungulates would be valuable.

For a short period immediately following birth it has been our finding that the instantaneous relative growth rate is of the order of 10 per cent per day. The nutritive quality of the milk of the doe during this early phase of growth must be superlative to permit such a rate of development. Additional information on this subject is needed. It is worthy of note that this rate is comparable to that of the domestic pig over the same phase. It will thus be apparent that the precise age must be known before an accurate expression of birth weights in wild caught young can be made. Not all our fawns have shown this initial phase and we are unable to explain this variability. Table 4 gives the growth constants, calculated from the formula $K = \frac{\ln W_2 - \ln W_1}{t_2 - t_1}$, for the three phases in ten fawns. The initial growth phase is sustained for only a very short period, in fact, in our hands, for about a week.

During the second, and somewhat longer,

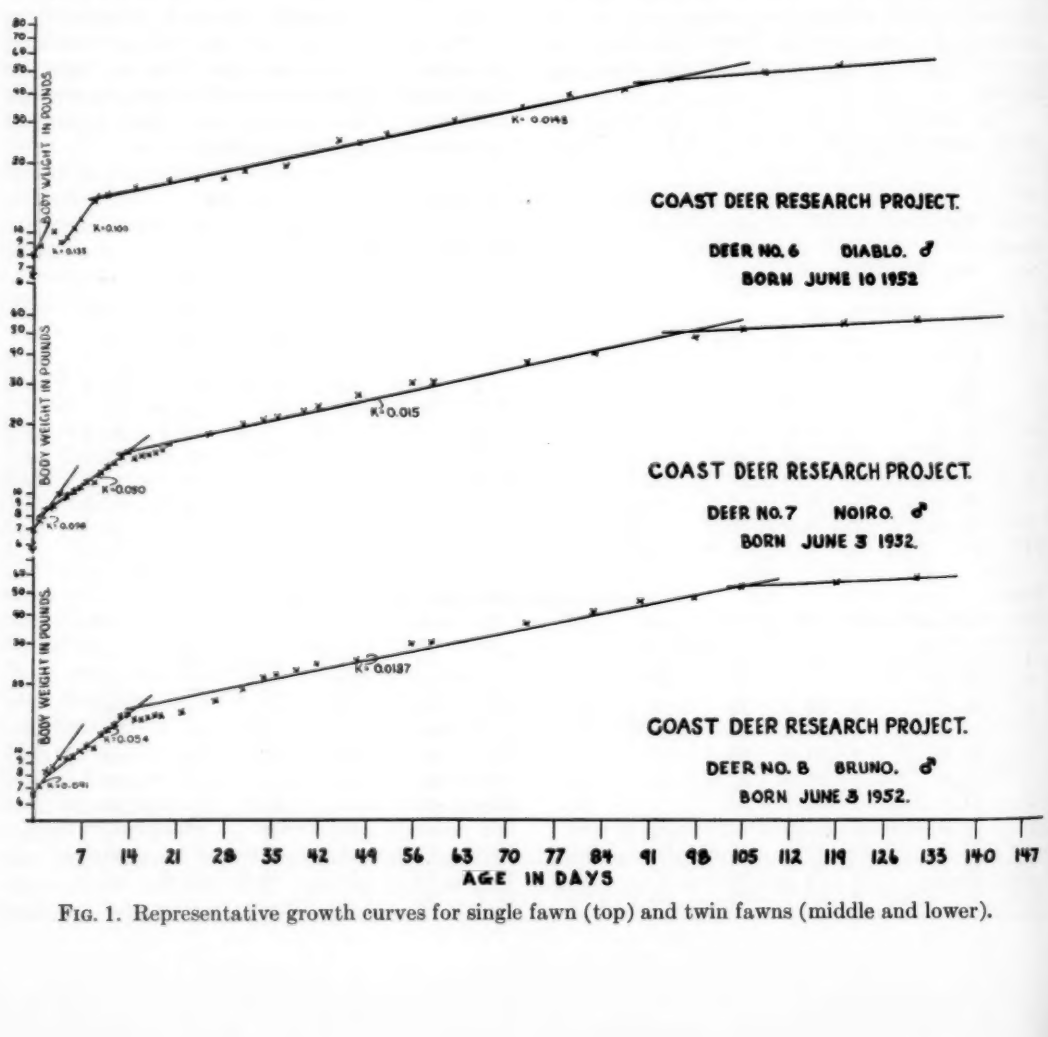

FIG. 1. Representative growth curves for single fawn (top) and twin fawns (middle and lower).

TABLE 4.—GROWTH RATE CONSTANTS FOR ALL ANIMALS

Deer No.	Phase I	Phase II	Phase III	Relation	Sex
1....	.080	.030	.011	) Twins	F
2....	..	.053	.012		M
3....	..	.049	.015	) Twins	M
4....	..	.049	.014		M
5....	..	.047	.011	Single	M
6....	.100	..	.015	"	M
7....	.098	.050	.015	) Twins	M
8....	.091	.054	.014		M
1 H...	.046	.148*	.0244		M

*The high constant is probably the result of the low growth rate (.046) of this animal during Phase I. See text.

growth phase the instantaneous relative growth rate is approximately 5 per cent per day (35 per cent per week) or about half that of the initial period. This phase covers the period from 7 to 21 days *post partum*. It is tempting to suggest that the end of this phase represents the beginning of the physiological preparation for subsequent life as a ruminant.

It will be evident that during these two phases of exceedingly active growth even minor inimical changes in environmental circumstances such as might influence rate of milk production of the doe or energy loss of the fawn will give rise to relatively major upsets to the normal growth pattern. Evidence from other species as suggested by McMeekan and Hammond, 1940 indicate that, while sidereal time may be regained, physiological time is irrecoverable and the extent to which it is irrecoverable is dependent upon the rate at which the physiological events are transpiring. In other terms, a setback when growth rate is high is likely to lead to animals that depart from the norm of the species.

On the other hand the relative uniformity of weights within the experimental animals on an adequate plane of nutrition (Table 3) at 105 days, keeping in mind that some were twins and some single births, and that 4 of the ten aborted Growth Phase 1, testifies to the ability of the animals to compensate for minor nutritive disturbances.

Our data permit the delineation of a third phase during which the instantaneous relative growth rate is approximately 1.5 per cent per day. This rate is sustained to the onset of puberty which appears to occur at approximately 100 days (Table 5) in males

TABLE 5.—APPROXIMATE WEIGHT AND AGE RELATIONSHIPS AT THE PUBERTAL BREAK IN THE GROWTH CURVE

Male Deer No.	Age in Days	Weight in Pounds
2.....	112	66
3.....	112	57
4.....	112	60
5.....	101	54
6.....	94	46
7.....	96	52
8.....	105	52
1H.....	129	60
2H.....	130	60

under our experimental conditions. We are uncertain of the time of puberty in females as our fawns have been predominantly males.

The interpretation of this third break in the growth rate as pubertal is suggested by the development of small, naked antler buds ($\frac{1}{2}$" in length), by the very evident sexual behaviour of male fawns of that age, supported by the fertile mating of fawns No. 1 and No. 2 during their fawn winter. Deer No. 5 was the product of this mating.

Application of sound analysis to individual animals reveals much information that becomes obscured when the data is treated so as to reveal population parameters. For instance, we have encountered several instances of setbacks in growth rate in the first two phases, followed by restoration to the inherent level. From this we conclude that radical departure from these growth rates are of environmental origin. For example, No. 1 H (Table 4) was one of twins born to a primiparous doe. The other twin made no weight gain after 11 days and died at 25 days at a weight of 8 lbs. We postulate that this doe was deficient in milk production and not until after No. 1 H was obtaining almost all the milk (after 11 days) was it able to achieve the growth rate of Phase 1.

The data on subsequent phases of the growth curve is in process of analysis. However, it may be of interest to record that we have kept only 2 bucks through to an age of 30 months. Each weighed in excess of 200 lbs.

As a further indication of physiological state at various intervals it is pertinent to comment on the precocial antler development of the experimental males. Almost all fawns have naked antler buttons up to ¾ inch long when 4–5 months old. At 15 months, when the wild stock usually have spike antlers, or at the most forked antlers, our animals have had 3 or even 4 point antlers with a spread of up to 12 inches.

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STUDIES OF THE EASTERN BROOK TROUT POPULATION AND FISHERY IN SUNKHAZE STREAM, MAINE

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INTRODUCTION

Maine's trout and salmon lakes have interested biologists since the early days of fishery science and have been the subject of many surveys and studies. Maine's trout streams have received much less attention. The present study was undertaken to provide information on the eastern brook trout, *Salvelinus fontinalis* (Mitchill), in a heavily fished, lowland stream considered typical of many in eastern and coastal Maine.

Sunkhaze Stream originates as a series of springs and hillside drainages in Twp. 32, Hancock County, flows north and west through Greenfield amd Milford, Penobscot County, and empties into the Penobscot River approximately 4.5 miles above the city of Old Town. Stream length is approximately 20 miles, total fall in elevation is approximately 550 feet, average width is 20 feet, and volume of flow midway between the source and the mouth is 12 to 15 c.f.s. at average water levels. The watershed is well protected by second-growth forest and stream flow is relatively stable. Overhanging alders provide dense cover along most of the stream.

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The eight-mile section of stream immediately above the mouth is deep and sluggish and is bordered by marshland. This area is inhabited by various warm-water fishes and is not considered trout water. Above the marsh the stream is essentially a series of short riffles and falls separated by long sections of quiet meandering deadwater. Trout fishing is concentrated in this area. The extreme headwaters are small and steep and are of little value for fishing.

The eastern brook trout is the only cold-water game fish present at Sunkhaze Stream. Non-game species include the following:

Catostomus commersoni (Lacépède)	White sucker
Semotilus corporalis (Mitchill)	Fallfish
Semotilus atromaculatus (Mitchill)	Creek chub
Rhinichthys atratulus (Hermann)	Blacknose dace
Chrosomus eos (Cope)	Redbelly dace
Notemigonus chrysoleucas (Mitchill)	Golden shiner
Notropis cornutus (Mitchill)	Common shiner
Anguilla rostrata (LeSueur)	American eel
Pungitius pungitius (Linnaeus)	Ninespine stickleback

Fishes known only from the lower, non-trout area of the stream include:

Amieurus nebulosus (LeSueur)	Brown bullhead
Esox niger (LeSueur)	Chain pickerel
Perca flavescens (Mitchill)	Yellow perch
Micropterus dolomieu (Lacépède)	Smallmouth bass

Lepomis gibbosus (Linnaeus) Pumpkinseed
Lepomis auritus (Linnaeus) Yellowbelly sunfish

Fishing regulations at Sunkhaze Stream fall under Maine's general law; the season opens on April 15 and closes on August 15, the bag limit is 15 trout or 5 pounds of trout, and the minimum legal length is 6 inches.

The work at Sunkhaze Stream included fishery and population studies of a limited section in the lower trout area of the stream, population and migration studies in the headwaters of the stream, and beaver-trout investigations in the headwaters of the stream. Results of the fishery and population studies in the lower part of the stream are discussed in this report. The latter phases of the project will be presented later.

METHODS

The existence of a single convenient route of access allowed a creel census of the lower 3.4 miles of the heavily fished portion of Sunkhaze Stream. This stream section has an average width of 15 feet, a water surface area of approximately 6.18 acres, and an average flow of 13–15 c.f.s. at moderate water levels. All major habitat types present at Sunkhaze Stream are represented. The "creel census area" embraces approximately one-third of the heavily fished section of the stream and probably furnishes one-third of the total trout catch. The larger trout taken at Sunkhaze are taken in the census area.

Creek censuses were conducted during the seasons of 1949, 1951, and 1952. The 1949 creel census was operated continuously between April 15 and June 10, and six days a week between June 10 and July 17. The 1951 and 1952 censuses were operated on the opening days of the seasons, weekends and holidays during the seasons, and the closing days of the seasons, August 15. Creel census clerks interviewed anglers as they returned to their cars at the close of their days' fishing. Data recorded included number of angling hours spent, type of lure used, number of trout creeled, and number of trout caught and released. Creeled trout were measured and weighed and scale samples were collected.

It is estimated that the censuses were approximately 90 per cent complete. Occasional anglers avoided the checking station by entering the census area over a more difficult route or failed to cooperate during the evening "rush". It was also occasionally impossible to get all desired information from each creel; some anglers had lost their fish, eaten their fish, gutted their fish and removed the heads, or were in a hurry and did not wish to be detained.

STATUS OF THE FISHERY

Census takers interviewed 2094 anglers at Sunkhaze Stream during the three census years. These anglers had spent 5936 fishing hours in the census area, had creeled 2191 trout, and had caught and released 1382 trout (mostly sub-legals). Yearly creel census results are shown in Table 1. The results are of partial censuses only; the 1949 census was operated during the first 14 weeks of the 18-week season only and the 1951–52 censuses were operated on opening and closing days and weekends and holidays only. Because estimates of the total fishery statistics for the three census years were desired for comparative purposes, the empirical totals were expanded as follows:

1. In both 1951 and 1952, approximately 89 per cent of the fishing effort in hours and 82 per cent of the catch were recorded during the first 14 weeks of the 18-week season. Seasonal trends in intensity of fishing effort and catch were essentially similar in the three census years. If it is assumed that similar parts of the total effort and catch were accumulated during the first 14 weeks of the 1949 season, total 1949 effort was $\frac{100 \times 3412}{89}$ or 3730 hours and total 1949 catch was $\frac{100 \times 1198}{82}$ or 1460 trout.
2. In 1949, 54 per cent of the fishing effort and 45 per cent of the catch were logged on weekends, holidays, and the opening day of the season. If these relationships held throughout the seasons of 1951 and 1952 and if the same procedure used above is applied, total fishing effort in 1951 was 2200 hours and total fishing effort in 1952 was 2450 hours. Similarly, 1951 catch was 950 trout and 1952 catch was 1260 trout.
3. It was estimated that the creel censuses were 90 per cent complete. Applying the above procedures and the values computed above, the following estimates of total catch and effort can be made.

TABLE 1.—FISHERY STATISTICS COLLECTED AT THE CREEL CENSUS AREA OF SUNKHAZE STREAM, 1949, 1951, AND 1952; PARTIAL CENSUSES ONLY

Statistic	1949*	1949**	1951***	1952***
Number of days censused	90	31	39	38
Number of anglers	1068	496	482	544
Total hours fished	3412	1842	1186	1338
Hours fished per acre	552	298	192	217
Number of trout creeled	1198	538	426	567
Pounds of trout creeled	167.7	...	90.3	115.7
Number of trout per acre	194	87	69	92
Pounds of trout per acre	27.1	...	14.6	18.7
Number of trout per hour	0.351	0.292	0.359	0.424
Pounds of trout per hour	0.049	...	0.076	0.084
Number of trout per trip	1.122	1.085	0.884	1.042
Pounds of trout per trip	0.157	...	0.187	0.213
Percent successful anglers	34	31	32	31
Length fishing day (hours)	3.19	3.96	2.46	2.46
Average total length (inches)	7.20	...	8.00	7.96
Average weight (pounds)	0.140	...	0.212	0.204
Number of short trout	850	...	141	391

* Complete census April 15 to June 10, six days a week from June 10 to July 17.

** Census on the opening day of the season and on weekends and holidays during the season until July 17.

*** Census on the opening and closing days of the season and on weekends and holidays during the season.

Year	Catch	Effort
1949	1620	4140
1951	1060	2440
1952	1400	2760

Table 2 gives final census area fishery statistics computed from the expanded catch and effort. The expansion of partial censuses cannot be accompanied with measures of error and it must be emphasized that total and per-unit-area catch and effort values should not be accepted as absolutes. Year to year trends, on the other hand, should be represented faithfully.

Marked improvement in the quality of the Sunkhaze Stream fishery during the four years covered by the creel census study is evident from Table 2. Despite a larger catch in 1949, catch per unit of effort increased consistently through 1952. Also significant is the increased harvest in pounds of trout per acre; larger trout were taken in the later census years.

Maine was subjected to severe drouth conditions during 1947 and 1948. Consequent low and unstable stream flow during those years may have contributed to the relatively poor fishing during 1949. More favorable conditions existed during 1949, 1950 and 1951. These conditions may be associated

TABLE 2.—ESTIMATED TOTAL FISHERY STATISTICS FOR THE CREEL CENSUS AREA OF SUNKHAZE STREAM, 1949, 1951, AND 1952

Statistic	1949	1951	1952	Average
Number of anglers	1298	992	1123	1138
Total hours fished	4140	2440	2760	3113
Hours fished per acre	670	395	447	504
Number of trout creeled	1620	1060	1400	1360
Pounds of trout creeled	226.8	224.7	285.6	245.7
Number of trout per acre	262	172	227	220
Pounds of trout per acre	36.6	36.5	46.3	39.8
Number of trout per hour	0.391	0.434	0.507	0.444
Pounds of trout per hour	0.055	0.092	0.104	0.084
Number of trout per trip	1.25	1.07	1.25	1.19
Pounds of trout per trip	0.175	0.227	0.255	0.219

with the improvement shown for the later census years. The severe drouth of the summer of 1952, while not reflected in the fishing quality of that year, may cause a recession in 1953 or 1954.

Table 3 is a compilation of comparisons between Sunkhaze Stream fishery statistics and those obtained by workers in other areas. In general, Sunkhaze Stream's trout fishery compares favorably with the fisheries of other test streams.

Many workers have commented upon the fact that small percentages of anglers often take large percentages of the catch. The degree to which the Sunkhaze Stream catch is maintained by the more skillful anglers is shown strikingly by the following: in 1951, 74 per cent of the total catch was reported by 12 per cent of the anglers; in 1952, 77 per cent of the catch was taken by 13 per cent of the anglers. Two especially skillful anglers took 22 per cent of the total weekend and holiday catch in 1951 and 20 per cent of the total in 1952. The general percentages of successful angling trips were surprisingly similar in the three census years; 31 per cent, 32 per cent, and 31 per cent.

Fly vs. Bait Fishing

Several states restrict trout fishing in selected areas to "fly fishing only." Such restrictions are usually enacted in hopes of (1) reducing the total catch, (2) reducing hooking injury to under-legal-size fish, or (3) preventing the introduction of undesirable species by live-bait fishermen. Factual information on the effect of fly fishing only is scarce and many fisheries workers and anglers question the value and fairness of such restrictions. The question is particularly pertinent to Maine where fly fishing only regulations are common. The creel census studies at Sunkhaze Stream provided an opportunity to compare bait and fly fishing in a stream open to both.

During the three census years, 25 per cent of all fishermen contacted had fished with artificial flies only, 65 per cent had fished with bait only (mostly worms), and 10 per

TABLE 3.—COMPARISONS OF THE SUNKHAZE STREAM FISHERY WITH TROUT FISHERIES OF OTHER STREAMS

Statistics	Location	Authority
1. Man-hours of angling per acre per year		
103	Michigan	Shetter, 1944
280	Michigan	Cooper, 1952
296	Michigan	Shetter, 1944
504	**Sunkhaze Stream**	Rupp, this report
2. Catch per hour		
0.3	Michigan	Shetter and Hazzard, 1941
0.4	Vermont	Lord, 1941
0.444	**Sunkhaze Stream**	Rupp, this report
0.45	Michigan	Shetter, 1944
1.68	Prince Edward Island	Smith, 1951
2.5	Manitoba	Doan, 1948
3. Pounds per hour		
0.067	Michigan	Shetter, 1944
0.084	**Sunkhaze Stream**	Rupp, this report
0.348	Michigan	Shetter, 1944
1.9	Manitoba	Doan, 1948
4. Catch in pounds per acre per year		
5.82	Michigan	Cooper, 1952
12.8	Michigan	Shetter, 1944
39.8	**Sunkhaze Stream**	Rupp, this report
64.7	Michigan	Shetter, 1944
5. Percentage of unsuccessful anglers		
41	Michigan	Shetter, 1944
57	Michigan	Shetter, 1944
69	**Sunkhaze Stream**	Rupp, this report
79	Michigan	Shetter, 1944

cent had used both. The success of the three groups was as follows:

	Legal-size trout		Under-size trout	
	Catch in per cent of total	Catch per trip	Catch in per cent of total	Catch per trip
Fly fishermen	42	1.750	50	1.330
Bait fishermen	49	.785	36	.360
"Both" fishermen	9	.981	14	.937

Fly fishermen were more than twice as efficient as bait fishermen in taking legal-size trout and almost four times as efficient as bait fishermen in taking short trout.

During 1951 and 1952, the average length of legal-size trout taken by fly fishermen was $8.33 \pm .08$ inches and the average length of legal-size trout taken by bait fishermen was $7.53 \pm .07$ inches. Test with "t" showed the difference to be highly significant; fly fishermen took larger trout than bait fishermen.

Restriction of Sunkhaze Stream to fly fishing would prevent at least 65 per cent of all anglers from fishing (or force them to change their fishing method) and would reduce the catch by only approximately 50 per cent. Elimination of competition from bait fishermen would probably allow the fly fishermen to be more successful and thus the catch would actually be reduced less than 50 per cent. It is possible that the catch would not be reduced at all but would just be divided among a smaller number of anglers. At any rate, it is safe to conclude that fly fishing only at Sunkhaze Stream would not reduce the catch in fair proportion to the number of anglers it would prevent from fishing. If it were necessary to reduce the catch at Sunkhaze Stream, a fairer approach would be the shortening of the open season or the lowering of the bag limit, measures equally restrictive to all classes of anglers.

Many proponents of fly-fishing-only regulations state their main object to be the reduction of hooking injury to small fish. If it can be shown that bait fishing causes a high and disproportionate mortality among undersize fish the value of such regulations will be established.

Where it is necessary to prevent the introduction of trash fish, as in newly reclaimed ponds, the value of fly fishing only is evident.

POPULATION STUDIES

Material for population analyses consisted of length observations, weight observations, and scale samples collected through creel census. Since angling does not provide a representative sample of a trout population but captures only the fast-growing members of each age group (Cooper, 1953b), the data presented below refer only to that portion of the population available to anglers.

Age and Growth

Ages of trout were determined by scale reading (proven valid for eastern brook trout by Cooper [1951]) and are given in numbers of annuli. Average lengths were computed from actual measurement; no lengths based on scale calculations are presented in this report.

Creels were examined during every month of the fishing season. Since the average length of fish of any age group would increase considerably during this period of fast growth, it was necessary to confine age determination to a group of fish examined during a relatively short period of time. Age determinations were made from scale samples collected during the month of June only. June was chosen because that was the month in which the greatest number of fish were caught. The ratios of abundance of the various age classes in the June catch were then applied to the whole season's catch to give the age and size composition of the season's catch as it would have been if all fish had been taken in June.

The application of the June age distribution to the season's catch was done by a method similar to Ketchen's (1950) method of stratified subsampling. Ketchen selected subsamples for age determination on the basis of a constant level for all size groups; the level dependent upon the configuration of the size-frequency polygon and the height of the mode. Ketchen's subsamples thus included all individuals in size groups less numerous than the subsampling level. Subsamples from well represented size groups were often as small as 17 per cent. In the procedure here presented, "subsamples" consisted of all individuals examined during June. In no case did the percentage of subsampling fall below 20 per cent. Most subsamples from poorly represented size groups were greater than 50 per cent and many were 100 per cent.

Tables 4, 5, and 6 show (1) yearly age and one-half-inch size class distributions of trout taken by anglers during June of 1949, 1951, and 1952 and (2) yearly age and size class distributions of the whole season's catch adjusted to the June age ratios.

TABLE 4.—DISTRIBUTION OF AGE AND ONE-HALF-INCH SIZE CLASSES OF TROUT IN THE JUNE SUBSAMPLE AND IN THE WHOLE SEASON'S CATCH ADJUSTED TO JUNE AGE RATIOS; SUNKHAZE STREAM, 1949

Size Class	June Subsample Age Class					Total Catch Age Class				
	n	I	II	III	IV	n	I	II	III	IV
6.0–6.4	41	36	5	..	..	201	176	25	..	..
6.5–6.9	48	22	26	..	..	174	80	94	..	..
7.0–7.4	40	8	32	..	..	153	31	122	..	..
7.5–7.9	36	4	32	..	..	120	13	107	..	..
8.0–8.4	26	..	25	1	..	74	..	71	3	..
8.5–8.9	23	..	16	7	..	54	..	38	16	..
9.0–9.4	15	..	4	11	..	34	..	9	25	..
9.5–9.9	5	..	1	4	..	13	..	3	10	..
10.0–10.4	8	..	..	8	..	16	..	..	16	..
10.5–10.9	3	..	..	3	..	6	..	..	6	..
11.0–11.4	5	..	..	5	..	7	..	..	7	..
11.5–11.9	3	..	..	3	..	6	..	..	6	..
12.0–12.4	3	..	..	3	..	3	..	..	3	..
12.5–12.9	2	..	..	2	..	2	..	..	2	..
13.0–13.4	1	..	..	..	1	2	..	..	..	2
13.5–13.9	2	..	..	..	2	3	..	..	..	3
14.0–14.4	..	..	..	..	..	..	..	..	..	..
14.5–14.9	..	..	..	..	..	..	..	..	..	..
15.0–15.4	1	..	..	..	1	2	..	..	..	2
15.5–15.9	1	..	..	..	1	2	..	..	..	2
Totals	263	70	141	47	5	872	300	469	94	9

TABLE 5.—DISTRIBUTION OF AGE AND ONE-HALF-INCH SIZE CLASSES OF TROUT IN THE JUNE SUBSAMPLE AND IN THE WHOLE SEASON'S CATCH ADJUSTED TO JUNE AGE RATIOS; SUNKHAZE STREAM. 1951

Size Class	June Subsample Age Class						Total Catch Age Class					
	n	I	II	III	IV	V	n	I	II	III	IV	V
6.0–6.4	16	6	10	..	..	..	39	15	24	..	..	..
6.5–6.9	18	8	10	..	..	..	53	24	29	..	..	..
7.0–7.4	21	4	17	..	..	..	58	11	47	..	..	..
7.5–7.9	24	1	20	3	..	..	63	3	52	8	..	..
8.0–8.4	11	..	3	8	..	..	40	..	11	29	..	..
8.5–8.9	16	..	3	13	..	..	27	..	5	22	..	..
9.0–9.4	15	..	4	11	..	..	30	..	8	22	..	..
9.5–9.9	8	..	..	8	..	..	24	..	..	24	..	..
10.0–10.4	7	..	..	7	..	..	14	..	..	14	..	..
10.5–10.9	8	..	..	6	2	..	9	..	..	7	2	..
11.0–11.4	2	..	..	..	2	..	8	..	..	..	8	..
11.5–11.9	4	..	..	..	3	1	6	..	..	..	4	2
12.0–12.4	2	..	..	..	2	..	5	..	..	..	5	..
12.5–12.9	*	..	..	..	..	..	2	..	..	..	1	1
13.0–13.4	*	..	..	..	..	..	1	..	..	..	..	1
Totals	152	19	67	56	9	1	379	53	176	126	20	4

* Size classes not sampled in June. The ages of the three fish in these two groups were determined from reading the scales.

TABLE 6.—DISTRIBUTION OF AGE AND ONE-HALF-INCH SIZE CLASSES OF TROUT IN THE JUNE SUBSAMPLE AND IN THE WHOLE SEASON'S CATCH ADJUSTED TO JUNE AGE RATIOS; SUNKHAZE STREAM, 1952

Size Class	June Subsample						Total Catch						
	Age Class						Age Class						
	n	I	II	III	IV	V	n	I	II	III	IV	V	VI
6.0–6.4	29	24	5	..	..	..	62	51	11	..	..	..	..
6.5–6.9	35	19	16	..	..	..	81	44	37	..	..	..	..
7.0–7.4	37	6	31	..	..	..	108	18	90	..	..	..	..
7.5–7.9	22	1	21	..	..	..	67	3	64	..	..	..	..
8.0–8.4	23	..	19	4	..	..	69	..	57	12	..	..	..
8.5–8.9	11	..	8	3	..	..	39	..	28	11	..	..	..
9.0–9.4	12	..	4	8	..	..	39	..	13	26	..	..	..
9.5–9.9	11	..	..	11	..	..	28	..	..	28	..	..	..
10.0–10.4	8	..	..	8	..	..	22	..	..	22	..	..	..
10.5–10.9	5	..	..	3	2	..	9	..	..	5	4	..	..
11.0–11.4	2	..	..	..	2	..	8	..	..	..	8	..	..
11.5–11.9	5	..	..	..	5	..	9	..	..	..	9	..	..
12.0–12.4	2	..	..	..	2	..	4	..	..	..	4	..	..
12.5–12.9	1	..	..	..	..	1	1	..	..	..	..	1	..
13.0–13.4	5	..	..	..	4	1	7	..	..	..	5	2	..
13.5–13.9	..	..	..	..	..	..	..	..	..	..	..	..	..
14.0–14.4	1	..	..	..	..	1	1	..	..	..	..	1	..
14.5–14.9	..	..	..	..	..	..	..	..	..	..	..	..	..
15.0–15.4	..	..	..	..	..	..	..	..	..	..	..	..	..
15.5–15.9	..	..	..	..	..	..	..	..	..	..	..	..	..
16.0–16.4	*	..	..	..	..	..	1	..	..	..	..	..	1
Totals	209	50	104	37	15	3	555	116	300	104	30	4	1

* Size class not sampled in June. The age of the fish in this group was determined from reading the scales.

As may be seen, calculated numbers of trout of each age taken by angling were as follows:

Year	Age Group					
	I	II	III	IV	V	VI
1949	300	469	94	9	..	..
1951	53	176	126	20	4	..
1952	116	300	104	30	4	1

In 1949, age IV fish comprised only 1.0 per cent of the total catch. Age IV and V fish comprised 6.3 per cent of the catch in 1951 and age IV, V, and VI fish comprised 6.3 per cent of the catch in 1952. Older fish appeared in each year's catch.

The average total length of trout taken by anglers during 1949 was 7.20 ±.03 inches. The 1951 and 1952 averages were 8.00 ±.08 and 7.96 ±.07 inches respectively. Test with "t" showed no difference between the 1951–1952 averages and a highly significant difference between those and the average of 1949. Larger fish were caught in the later census years.

The trend toward older and larger trout in 1951 and 1952 may be associated with the improvement in fishing quality shown for those years and may reflect the progress of a recovery of the trout population from unfavorable conditions in the years immediately preceding 1949. The need of long-term studies to record such trends is apparent.

The three-year average length of the 1806 trout examined was 7.72 inches. A comparison of this average with average lengths of trout taken by anglers in other areas is presented in the following table.

Average length	Location	Authority
6.5	Vermont	Lord, 1946
7.0	Prince Edward Island	Smith, 1951
7.5	Michigan	Shetter, 1944
7.72	**Sunkhaze Stream**	Rupp, this report
8.4	Michigan	Shetter, 1944
9.1	Michigan	Shetter, 1944

The average lengths of trout taken from each age group each year and the grand averages for the three years are shown in the following table. Numbers in parentheses are

numbers of length observations averaged. Average lengths were not computed for numbers of fish less than twenty.

Year	Age Class I	II	III	IV
1949	6.50±.02 (300)	7.49±.03 (469)	9.83±.11 (94)	....
1951	6.72±.06 (53)	7.33±.05 (176)	9.08±.07 (126)	11.58±.03 (20)
1952	6.54±.00 (116)	7.48±.06 (300)	9.54±.11 (104)	12.00±.22 (30)
Three-year average	6.53 (469)	7.46 (945)	9.45 (324)	11.83 (50)

It must be emphasized that the preceding table gives observed lengths adjusted to the month of June. If lengths at annulus formation based on scale calculations were presented, values would be less.

It should be further emphasized that the average lengths of age groups apply only to the faster-growing individuals liable to capture by angling. The legal size of 6 inches introduces a further error in that only the extremely fast-growing age I individuals are represented.

Condition

The condition factor of trout angled at Sunkhaze Stream was computed from the formula $C = \frac{100{,}000\ W}{L^3}$ which had been described and discussed at some length by Hile (1936). Alignment charts prepared by the Montana Department of Fish and Game and described by Phenicie and Bishop (1950) were used to speed the calculations.

The average condition factor found among Sunkhaze trout in 1949 was 37.36 ±.55. Condition factors found in 1951 and 1952 were 41.52 ±.25 and 40.37 ±.22 respectively. Tests with "t" showed no difference between the 1951 and 1952 conditions and a highly significant difference between those and the condition of 1949. Trout taken by anglers during the later census years were relatively heavier.

The table below gives condition factors for trout taken each month during the three census years. Numbers in parentheses indicate numbers of individual condition factors averaged.

Year	Month April	May	June	July	August
1949.....	33.65±.58 (47)	37.58±.56 (104)	39.05±.49 (94)	37.06±.55 (26)	.....
1951.....	35.8 (5)	42.74±.64 (82)	43.41±.43 (134)	40.30±.38 (99)	37.55±.60 (44)
1952.....	32.9 (10)	39.57±.30 (185)	42.12±.46 (100)	41.98±.40 (124)	36.95±.50 (67)
Average.....	33.70 (62)	39.71 (371)	41.77 (328)	40.80 (249)	37.19 (111)

Cooper (1953a) computed condition factors (R) for brook trout collected from Hunt Creek, Pigeon River, and the North Branch of the Au Sable River at various times throughout the year. R is equal to $\frac{C}{22.038}$. Average condition factors found in the North Branch of the Au Sable River between April and August may be converted to C and listed as follows:

	Month April	May	June	July	August
"C"	34.16	39.23	40.99	38.77	37.68

Sunkhaze and Au Sable River condition factors are very similar. Early season condition of trout in each instance was well below each season's average. Condition improved rapidly during the early season, reached its highest value in June, then declined during the hot part of the summer. Condition factors at the Au Sable River reached their lowest value (C = 30.41) during February.

Survival

Information on the number of fish belong-

ing to the various age classes in a stable population may be used to estimate the percentages of fish that survive from one year to the next. Jackson's (1939) well-known formula, $S = \frac{x_2 + x_3 + x_4 + \ldots x_n}{x_1 + x_2 + x_3 + \ldots x_{n-1}}$, may be used to estimate the average annual survival of all age groups. Mortality is the complement of survival. Survival or mortality are usually measured using data resulting from one of the various methods of total population estimate. Fishery data may be used, however, if (1) the population is stable from year to year, and (2) the various age classes are uniformly sampled by the fishing method used.

The 1951 and 1952 Sunkhaze Stream trout fisheries cannot be considered stable; fishing quality was higher in 1952 and the population was probably greater in 1952. Further, the various age classes are known not to have been uniformly sampled; angling captured only the fast-growing members of each group and the legal size of 6 inches forbade retention of many age I individuals available to angling. A rough estimate of annual survival can be made, however, if 1951 and 1952 data are combined and if age group I is entirely omitted from the calculations.

Estimated survival of age group II fish to age III in 1951 and 1952 was $\frac{230}{476} = 48.3$ per cent. Survival of age III fish to an age of IV was 21.7 per cent, survival of age IV fish to age V was 16.0 per cent, and survival from age V to age VI was 12.5 per cent. Average annual survival of all age classes above I was 37.8 per cent. Average annual mortality of all age classes above I was 62.2 per cent.

Schuck (1945), working with wild brown trout, *Salmo trutta* Linnaeus, in Crystal Creek, New York, found an annual average survival of all ages of 36.1 per cent. Needham, Moffett, and Slater (1945) found the average overwinter survival of all age groups of wild brown trout in a California stream to be 40.0 per cent.

No attempt was made to separate fishing mortality from natural mortality in the Sunkhaze Stream study. The unmistakable trend toward older and larger fish in each year's catch may indicate, however, that fishing has contributed but a small part of Sunkhaze's annual average mortality in recent years. Anglers seek the more desirable larger and older fish and would tend to create a continuously younger and smaller-sized population if fishing mortality were great.

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SUMMARY

Creel censuses were operated during 1949, 1951, and 1952 at Sunkhaze Stream, a heavily fished eastern-brook-trout stream considered typical of many in lowland sections of eastern and coastal Maine. Creel census provided information on fishing quality and efficiency of fishing methods. Examination of creeled trout provided data on age composition, rate of growth, average size, condition, and survival of the portion of the population available to anglers.

1. Fishing quality improved markedly during the four-year period 1949 through 1952. Numbers and sizes of trout creeled compare favorably with averages cited by workers in other northern and eastern areas.

2. Fly fishermen were more than twice as efficient as bait fishermen in taking legal trout and almost four times as efficient as bait fishermen in taking short trout. Fly fishermen took significantly larger trout than bait fishermen. Restriction of Sunkhaze Stream to "fly fishing only" in an attempt to reduce the total catch would not reduce the catch in fair proportion to the number of anglers it would prevent from fishing.

3. The healthy and improving condition of Sunkhaze's trout population is shown. Improvement may be the result of more favorable weather conditions in recent years.

The present fishing intensity is not endangering the continued natural maintenance of the population and no need for stocking hatchery reared trout can be shown.

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RESULTS OF CONTROLLED DEER HUNTS ON THE TAMARAC NATIONAL WILDLIFE REFUGE [1]

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A fair number of deer were on the Tamarac National Wildlife Refuge in northwestern Minnesota when it was placed under rigid protection in 1937—two years after land purchase was initiated. This herd increased in typical irruptive form as a result of protection and probably reached a population peak in the fall of 1942. The first comprehensive deer-browse survey, made in April 1950 by state and federal personnel, pointed out the need for opening the refuge to deer hunting. Because of a statewide closed season in Minnesota in 1950, however, the first controlled hunt was not held until November 1951. Later similar controlled hunts were held in 1952 and 1953.

The objectives of this study were to measure the effect of controlled deer hunting on range recovery, and on the average weight, sex ratio, productivity, and age composition of the deer population.

Description of the Area

The refuge is located in central Becker County in northwestern Minnesota. It lies about 20 miles southwest of Itasca State Park, also a well-known deer area.

The gross area of the refuge is approximately 40,000 acres, of which 32,000 acres may be classed as deer range. Slightly more than 29,000 acres are now under federal ownership. About 10,000 acres still under state and private ownership are confined largely to the southern portion of the area.

The refuge is located within one of two series of morainic drift knolls and hills that extend from north to south through the central portion of the county. Much of this morainic drift consists of clay, till, and boulders. Parts of it also contain gravel and sand. The soils have been classified in the Nebish-Rockwood Association.

The tract lies within the transition zone between hardwoods and coniferous forest. Formerly the upland was covered with virgin stands of red pine, white pine and hardwoods. White pine and hardwoods were most common on heavier soils, while jack pine and red pine occupied gravel ridges and the more level sandy plains. Most swamps still support mixed stands of spruce, balsam fir, and tamarack. White cedar, an important deer food, does not occur on the refuge.

About 70 per cent of the area is forested and includes the following major cover types: aspen 37 per cent; oak 14; upland brush 13; bottomland hardwood 13; bottomland conifers 12; lowland brush 8; jack pine 2; and mixed hardwoods one per cent. The nonforested land is made up of 64 per cent lake surface (19 lakes within the refuge), 13 per cent marsh, and 3 per cent roads. Less than one per cent makes up the Ottertail River and its tributaries.

Since 1946, approximately one million board feet of saw-timber and 8,000 cords of pulpwood have been cut. This was done to increase shrubs and tree reproduction useful to deer and other wildlife. Eighty per cent of the timber cut was jack pine and much of the rest was aspen.

In late years forest fires have been unimportant. Only one 20-acre tract of timber has been destroyed by fire since the refuge was established.

Population Behavior

The Tamarac Refuge and the entire county were closed to hunting in 1937. In 1938 the refuge deer population was estimated at 3 per square mile on poor range and 12 deer

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per square mile on the best range. By 1939 it was estimated at 19 per square mile, and increases followed until it reached an estimated 22 deer per square mile, or 1,300 on the refuge in the fall of 1942. Deer drives were made on two representative sample areas in 1939, 1940, and 1942. One of the drive areas showed a peak population of 37 deer on 640 acres (November 1940) and the highest count on another area was 37 deer on 700 acres. These data indicate that the population probably reached an average of 30 deer per square mile or approximately 2,000 on the refuge.

The first account of deer mortality is contained in the refuge manager's report covering the first three months in 1943 when he wrote, "There was some indication that a number of deer were lost during the past 4 months. The winter was hard on them, especially in March when the snow became deeper."

In the fall of 1944 the population estimate was 1,000 deer and until 1951 population estimates fluctuated around this number. Beginning in 1947, estimates were based on airplane strip counts usually made in February each year. It should be stressed that the accuracy of these counts is influenced a great deal by weather conditions which affect the distribution of deer and by individual differences in the ability of observers to see deer from an airplane. Also, severe winters with deep snow and low temperatures apparently attract more deer to the refuge than do mild winters.

Closed seasons in Becker County in 1937, 1939, 1941, and 1950 helped to increase the number of refuge deer while heavy kills around the refuge (1944–1948) appear to have held the herd in check. Also, a light mortality in the winter of 1947–1948; heavy mortality in the winter of 1949–1950; and medium mortality in the winter of 1950–1951 have reduced the herd.

EFFECT ON THE RANGE

The first reference to heavy browse use may be found in the refuge manager's report for the period November 1, 1941, to February 1, 1942. He reported excessive use of red osier dogwood, light use on paper birch and basswood shoots, and occasional browsing on balsam fir. No food shortage was indicated, although the supply must have declined rapidly, since deer mortality was heavy the following winter.

After the first die-off, consumption of jack pine and balsam fir browse increased. By the winter of 1946–47, there was a definite browse line on smaller jack pine stands and a marked browse line on all the balsam fir. Sumac, a highly preferred browse, was being killed by excessive use. In April 1950 a browse survey showed that 10 species formed 87 per cent of the deer's diet and 5 of them made up 74 per cent of the food eaten. The five browse species were beaked hazelnut, red osier dogwood, fire cherry, willow, and bur oak. The survey also revealed that highly preferred species such as sumac, bur oak, and red osier dogwood were being killed off. Also beaked hazelnut, a second-rate browse species, was killed in some areas because of excessive use.

HUNTING SEASON RESULTS

Number of Hunters and Kill—No limitations were placed on the number of hunters although it was planned to restrict the number if the refuge attracted too many. All hunting was done on a first-come basis.

In 1951, about 5 inches of snow lay on the ground on opening day. In the four-day season, an estimated 1600 individual hunters were on the refuge, and the season kill for the 18,300-acre open area was 690 deer, or 25 per square mile (Table 1, Fig. 1). The percentage of success ranged from 19 the first day to about 10 per cent the second day (Table 2). For the season, 43 per cent of the hunters were successful. There were no hunting accidents, although the hunter density was one per 14 acres. Also, strip counts made soon after the season closed indicated that crippling loss was negligible.

A tally of successful hunters showed that about 75 per cent of them resided in counties in the vicinity of the refuge. About 36 per cent of all successful hunters were from Becker County.

In 1952, the southwest half of the refuge (20,000 acres), or about 14,000 acres of deer range, was open to hunting. About half of this portion of the refuge is owned by the federal government and the rest is in state and private ownership. Deer were hunted on federal lands for the first time although non-federal lands have been hunted each year during regular deer seasons.

The 1952 four-day hunt opened without

TABLE 1.—NUMBER OF HUNTERS AND KILL BY DAYS

Year	Checking Stations										Estimated Number Individual Hunters Using the Refuge (Including Camp Hunters)
	First Day		Second Day		Third Day		Fourth Day		Total		
	Hunters	Deer	Hunters	Deer	Hunters	Deer	Hunters	Deer	Hunter Days	Deer	
1951.....	1,300	255	1,434	137	844	108	866	141	4,444	641 49* 690	1,600
1952.....	2,500	285	2,145	74	735	18	400	4	5,780	381 183* 564	3,000
1953.....	1,654	191	1,439	77	..	..	..	..	3,093	268 65* 333	2,000

* Camp deer killed on open area but not checked at stations.

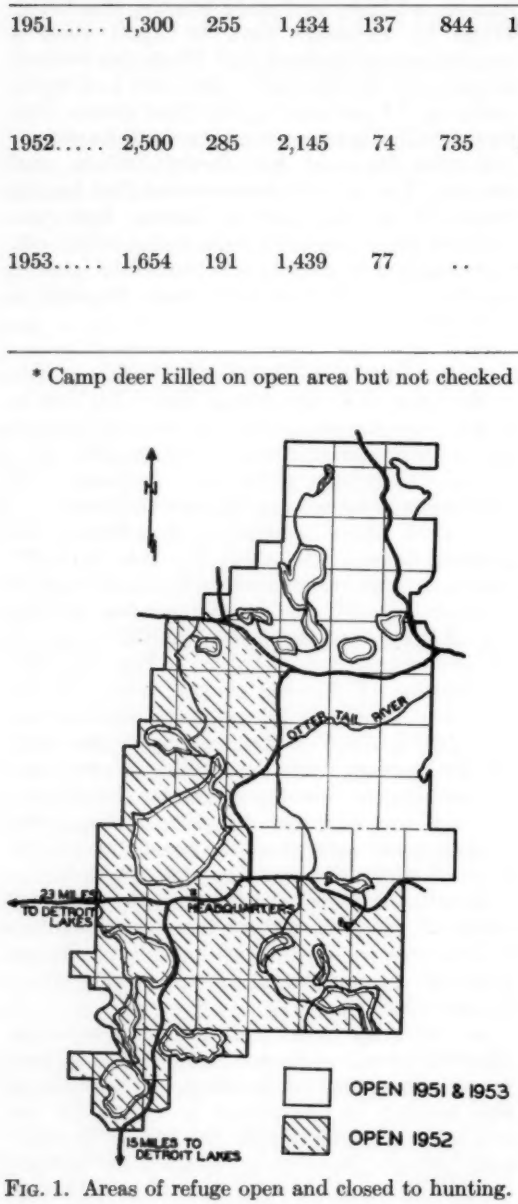

FIG. 1. Areas of refuge open and closed to hunting.

snow. Nevertheless, an estimated 2,500 hunters bagged 285 deer the first day. The season kill was estimated at 564 deer, or 25 per square mile (Table 1). At the checking stations 381 of these were examined. Hunter success was about 11 per cent the first day and one per cent the last day. Approximately 3,000 individual hunters used the refuge and 19 per cent were successful. Seventy-eight per cent of the successful hunters resided in counties in the refuge area. Forty per cent of all successful hunters were from Becker County. Although hunter density was one hunter per 6 acres, there were no accidents. Also field checks indicated crippling loss was low.

The 1953 season opened without snow, and "bluebird" weather was encountered during the short two-day season. Weather conditions were very similar to those in the 1952 season. On opening day approximately 1,700 hunters were tallied at the checking stations and the kill was 191 deer. For the two-day season an estimated 2,000 individual hunters killed 333 deer. About 17 per cent of the hunters were successful. Eighty per cent of the successful hunters were from counties in the refuge area and about half were from Becker County. Hunter density was one hunter per 10 acres and for the third year in a row there were no accidents. Also crippling loss was found to be negligible.

Distribution of Fawn and Adult Kill—In

TABLE 2.—PER CENT OF KILL AND PER CENT OF SUCCESSFUL HUNTERS BY DAYS

Year	First Day		Second Day		Third Day		Fourth Day		Estimated Hunter Success for the Season
	Kill	Hunter Success	Kill	Hunter Success	Kill	Hunter Success	Kill	Hunter Success	
1951.....	40	19.6	21	9.5	17	12.8	22	16.3	43[1]
1952.....	75	11.4	19	3.4	5	2.4	1	1.0	19[2]
1953.....	71	11.5	29	5.3	..	..	..	..	17[1]

[1] Same portion of refuge hunted twice.
[2] Portion of refuge hunted once only.

1951, 641 deer passed through the checking stations. Thirty-one per cent were fawns, and sixty-nine per cent yearlings and adults. It is important to note that the sex ratio was quite even among the fawn deer, while for the older deer there were almost 2 does for each buck (Table 3).

In 1952, 377 deer checked consisted of 35 per cent fawns. Among older deer, again the does outnumbered bucks by a ratio of slightly more than 2 to 1 (Table 3).

The 1953 sex data obtained on 266 deer are shown in Table 3. It appears that the sex ratio became more even among older deer.

Dressed Weight of Deer—During the three hunting seasons, weight information was secured on 1,267 deer—197 female fawns, 216 male fawns, 559 does, and 197 bucks (Table 4). An examination of the weight data shows that the bucks maintained an average weight of 168 pounds in

TABLE 3.—NUMBER AND PER CENT OF KILL—ADULTS AND FAWNS

Year	Adult Deer				Fawn Deer				Total Number
	Buck		Doe		Male		Female		
	No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent	
1951.....	153	24.0	287	45.0	106	16.0	95	15.0	641
1952.....	73	19.4	172	45.6	71	18.9	61	16.1	377
1953.....	79	29.7	106	39.8	40	15.0	41	15.5	266

TABLE 4.—AVERAGE DRESSED WEIGHT OF DEER (POUNDS)[1]

Year	All Fawns		All Yearlings and Adults		Weight by Age Class									
					1½		2½		3½		4½		5½	
	Male	Female	Buck	Doe	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀
1951.....	66*	62*	168	125*	118	108	151	121	150*	125	189	127*	183*	132**
1952.....	74*	71*	168	129*	125	110	143	122	176*	126	195	137*	218*	140**
1953.....	79*	76*	157	126	125	115	151	122	169	133	161	140	185	128*

Year					6½		7½		8½		9½–10½	
	Male	Female	Buck	Doe	♂	♀	♂	♀	♂	♀	♂	♀
1951.....	66*	62*	168	125*	192	129	185	125**	195	133	185	122
1952.....	74*	71*	168	129*	198	140	168	141**	208	132	200	128
1953.....	79*	76*	157	126	212	131	209	135	192	131	...	129

[1] Viscera removed but often the liver and heart remained in the carcass.
* Significant at 1% level.
** Significant at 5% level.

TABLE 5.—SEX RATIO AND FAWN PRODUCTIVITY

Year	Per cent of Kill		Fawn Per Doe Ratio	Sex Ratio—Males : 100 Females		
	Fawn	Adult	Fawns : 100 Females	Fawn	Adult	All Deer
1951.....	31.0	69.0	70 : 100	111 : 100	53 : 100	68 : 100
1952.....	35.0	65.0	76 : 100	116 : 100	42 : 100	62 : 100
1953.....	31.0	69.0	77 : 100	98 : 100	75 : 100	81 : 100

1951 and in 1952 and then dropped to an average of 157 pounds in 1953. In contrast the average weight of does increased by four pounds from 1951 to 1952 and decreased again by three pounds in 1953. The fawn deer showed the greatest weight increase for the three-year period—13 pounds for the males and 14 pounds for the females.

Apparently the deer harvests and winter weather have influenced the weights of the adult bucks and does in three ways: first, the average age of the herd has been reduced and many heavy older deer have been removed; second, the improved browse supply has made it possible for many deer to increase their weight; and third, the last two winters have been mild and permitted the deer to range over a wider area.

Apparently the fawns became heavier because they were offspring of more healthy does. Also the improved summer and fall range may have been responsible for the increased weights.

Fawn Productivity and Sex Ratio—The ratio of fawns per adult doe has been used as an indicator of fawn productivity in Itasca and St. Croix State Parks, where the number of fawns per doe increased steadily during successive hunting seasons. A similar finding was noted on the Tamarac Refuge as the ratio increased from 70 to 77 fawns per 100 does during the three-year period (Table 5). Also, the sex ratio information has shown that the number of males per 100 females increased from 53 in 1951 to 75 in 1953.

Relation of Hunting to Age—The age of the deer was determined by the method described by Severinghaus (1949). A review of three years' data (Table 6) points out some things that lack a satisfactory explanation. Although it is assumed that the age classes of deer killed are representative of the living population, this may not be the case. Variables which could influence age class sampling are: length of open season; weather, especially the presence or absence of snow; misaging, especially between the $1\frac{1}{2}$ and $2\frac{1}{2}$ year

TABLE 6.—DISTRIBUTION OF KILL BY SEX AND AGE CLASS (PER CENT)

Age—Years	Male			Female			All Deer		
	1951	1952	1953	1951	1952	1953	1951	1952	1953
$\frac{1}{2}$.....	16.1	19.0	15.4	15.0	16.6	15.7	31.1	35.7	31.1
$1\frac{1}{2}$.....	3.2	5.4	10.4	5.9	7.6	8.4	9.1	13.0	18.8
$2\frac{1}{2}$.....	1.7	1.9	7.7	4.5	3.3	7.7	6.2	5.2	15.4
$3\frac{1}{2}$.....	4.2	3.5	3.1	10.0	10.9	2.4	14.2	14.4	5.5
$4\frac{1}{2}$.....	2.8	2.7	.8	9.8	7.9	3.8	12.6	10.6	4.6
$5\frac{1}{2}$.....	2.8	1.3	1.9	7.9	9.0	7.7	10.7	10.3	9.6
$6\frac{1}{2}$.....	1.9	2.7	1.9	4.3	3.8	4.5	6.2	6.5	6.4
$7\frac{1}{2}$.....	1.3	.3	1.9	3.0	1.3	1.9	4.3	1.6	3.8
$8\frac{1}{2}$.....	1.3	.6	1.2	2.8	.6	2.4	4.1	1.1	3.6
$9\frac{1}{2}$.....	.2	.3	..	.2	.5	..	.4	.8	..
$10\frac{1}{2}$.....	.4	..	..	.7	.8	1.2	1.1	.8	1.2
Average Age of Herd (Years)	2.7	2.1	2.3	3.6	3.2	3.2	3.3	2.8	2.8
Average Age of Adults—$2\frac{1}{2}$ Years and Older.....	5.2	4.7	4.4	5.0	4.9	5.2	5.1	4.8	4.8

classes; hunter selectivity of sexes and certain age groups; differences in vulnerability of age classes to hunting; effect of winter mortality on strength of year classes; and errors resulting from sampling different halves of the refuge each year.

Age information in 1951 indicated that the percentage of kill by age classes followed the usual pattern with the exception of the weaknesses shown in the 1½- and 2½-year-old age classes. The weaknesses in these two age classes may be due to previous heavy fawn mortality such as was encountered in the winter of 1949–50. A heavy mortality in the fawn crop of 1949 may account for the low take of 2½-year-olds at hunting time in 1951. Also, a low survival of fawns born in the spring of 1950 may be responsible for the weakness in the 1½-year-old age class.

In 1952 a similar weakness was found in the 1½ and 2½ age groups. Since the 1½-year-old deer group was weak in 1951, it showed a similar weakness both in 1952 and 1953. However, the 2½-year-old group which was weak in 1951, formed a strong group in 1952 instead of a weak one as anticipated. In contrast the 1953 age data show strong 1½- and 2½-year-old age classes and weak 3½- and 4½-year-old age groups.

Findings similar to the results obtained at the Tamarac Refuge have been reported from the Big Levels Refuge in Virginia by Engle and Hanlon (1952). This refuge which was hunted for the first time in 1951, also showed weak 1½ and 2½ year age classes. No explanation was given.

So far hunting at Tamarac Refuge has influenced the sex and age composition of the herd, as shown by the increased percentages of fawns and yearlings in the kill: 40 per cent in 1951; 49 per cent in 1952; and 50 per cent in 1953. Also hunting appears to have reduced the average age of the herd by one-half a year (3.3 to 2.8). The males which averaged 2.7 years in 1951 decreased to 2.1 years in 1952 and increased slightly in 1953 to 2.3 years. The females also decreased from 3.6 years in 1951 to 3.2 years in 1952 and 1953.

SUMMARY AND CONCLUSIONS

1. Prior to opening the Tamarac Refuge to hunting estimates placed the deer population at 3 per square mile on poor range and 12 per square mile on the best range in 1938; 19 deer per square mile in 1939 and 22 per square mile by the fall of 1942. One deer drive made in the fall of 1940 showed a population of 37 per square mile. Severe winters, starvation, and heavy kills along the refuge boundary have kept the herd from increasing.

2. Preferred browse species such as sumac, bur oak, and red osier dogwood have been reduced in abundance by excessive deer use. Beaked hazelnut, a second rate browse species, now furnishes about half of the browse supply and in some areas it has also been killed off.

3. The 62-square-mile refuge has been open to deer hunting with firearms during 1951, 1952, and 1953. Each year about half of the refuge has been open under an alternating system.

4. Checking stations were manned to obtain information on weight, sex, age, and residence of successful hunters.

5. The quota was set at 600 deer in 1951 and 690 were killed. In 1952 the take was established at 700 deer or four days of hunting and 564 deer were killed. The 1953 quota was set at 300 deer or four days of hunting and 333 deer were bagged in two days. Limited checks on crippling loss indicated it was light all three years.

6. During the three open seasons a total of 6,600 hunters bagged 1,587 deer for a success ratio of 24 per cent. There were no hunting accidents.

7. Fawns made up 31 per cent of the kill in 1951 and 1953 and 35 per cent in 1952. Fawn productivity increased from 70 fawns per 100 does in 1951 to 77 in 1953.

8. After three years of hunting the adult sex ratio has tended to become more even. The males increased from 53 per 100 females in 1951 to 75 in 1953.

9. Average weight data on 1,270 deer has shown the following changes: the fawns increased 13 and 14 pounds; the does first increased 4 pounds and then decreased 3 pounds; the bucks stayed the same for two years and then decreased 11 pounds.

10. During the first two seasons the percentage distribution of the kill by age classes was much alike. Both showed a weakness in the 1½- and 2½-year-old age classes. The weak 1½ year class in 1951 was also weak in 1952 and 1953. However, the weak 2½ year class in 1951 appeared as a strong 3½ year class in 1952 although it should have been weak. In contrast the 1953 data show strong

$1\frac{1}{2}$ and $2\frac{1}{2}$ year groups and very weak $3\frac{1}{2}$ and $4\frac{1}{2}$ year classes.

11. The average age of the herd has been reduced by one-half of a year (3.3 to 2.8) and remained at that level for two years.

12. Seventy-three per cent of Minnesota's 87 counties are represented in the successful hunter group. Residents of Becker County and other counties in the refuge area kill about three-fourths of the deer each year.

13. If action had been taken in the fall of 1942 and about 35 per cent of the deer population had been removed annually, it seems probable that about 6,000 deer could have been harvested over the 9-year period (1942–1950). This would have meant orderly hunting seasons, about 4 times more deer for the hunters, but more important than these, the protection of the deer range from severe overbrowsing and lowered carrying capacity resulting from such overutilization.

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A MICROENVIRONMENT CONCEPT OF THE EPIZOOLOGY OF AVIAN BOTULISM

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Extensive studies of botulism epornitics by the Fish and Wildlife Service and by several state conservation agencies have led to the application of various devices and measures for control of the disease. In general, the methods of control have been applied (1) to the gross environment in efforts to alter or prevent the occurrence of the major environmental phenomena thought to be requisite for the development of botulism, or (2) to the fowl themselves to drive them from noxious areas. The efficacy of these measures has sometimes been questioned because of the wide variation in mortality rates under grossly similar conditions irrespective of control measures. It has been felt that more intimate knowledge of the genesis of epornitics would be desirable for the formulation of control measures, or at least for the elimination of measures which may be inadequate or ineffective. In order to obtain this information, the Denver Wildlife Research Laboratory of the Fish and Wildlife Service and the Rocky Mountain Laboratory of the U. S. Public Health Service are cooperating in studies of avian botulism in the field and in the laboratory. The present paper is based on some of these studies.

Salient among the problems of the epizoology of botulism are questions of the medium or substrate upon which the specific organisms grow and produce their toxin and of the form in which toxin is ingested by waterfowl. With regard to the latter, it is not known whether the toxin is ingested in selected food or in the act of drinking. Major obstacles to the solution of this problem are that the gastrointestinal tracts of intoxicated birds are usually empty of recognizable food particles, and one cannot accurately predict when birds will become intoxicated so that they may be collected and examined before digestion of food has occurred. The problem must, therefore, be approached from the viewpoint of the first question, and the leads which have developed from this approach are presented here.

A number of reports, theses, and publications on the subject have been found to support a general theme which may be termed

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the "sludge-bed hypothesis." This hypothesis supposes (1) that *Clostridium botulinum* exists in the mud or soil of lakes, marshes, or flooded fields; (2) that under certain conditions such as the ripening of aquatic plants or the flooding of fields, large quantities of decaying organic matter are made available to the bacteria; and (3) that aerobic bacteria exhaust the oxygen as a prerequisite to the activity of the anaerobic clostridia which then proliferate and secrete toxin. In effect these conditions would resemble liquid sewage overlying a sludge bed. In the sludge-bed hypothesis, temperature, pH, and dissolved salts in the water are considered important corollary factors. It is not implied that this concept is held universally, but it has been explicit or implicit in much of the writing on the subject.

As a result of our studies we have become impressed with an alternative concept which will be labeled the "microenvironment concept." Some observations basic to this theory have been reported by others, and it is felt that our data tend to substantiate these observations and to bring them into focus upon the problem at hand. Briefly stated, we believe (1) that *C. botulinum* type C germinates, reproduces, and synthesizes its toxin in small discrete particulate substances, possibly invertebrate carcasses; (2) that the particulate substances are in no wise dependent upon the ambient medium for nurture of the bacteria, but contain all of the requisites within them; and (3) that the toxin is probably in the bacteria which reside in the particulate materials, rather than in the form of soluble, freely diffused toxin. In the latter regard our observations agree with those of Dozier (1924) and of Prévot and Brygoo (1953) and are in accord with the fact that intoxicated birds so frequently have botulinum spores in their livers—indicating an association of toxin with the bacteria at the time of ingestion.

The microenvironment concept has developed from consideration of historical data of the epizoology of botulism caused by the type C organism and from observations in the laboratory and in the field. Only limited reference will be made here to the pertinent literature and experimental work (for further references see Reports of the Cooperative Botulism Studies). In the classical studies of Theiler *et al.*, (1920) on the epizoology of lamsiekte in cattle, a disease caused by the type C toxin, it was found that ". . . in the lamsiekte areas dead animal matter is practically the only source of danger." They stated further ". . . so long as the carrion of even the smallest beast of the field is there, so long can a small mortality from lamsiekte be expected at certain seasons of the year. . . ." They listed a series of small vertebrate hosts of the toxin and also investigated the role of sarcophagid larvae as carriers of the toxin from the carcasses of vertebrates. Subsequent studies in the United States and in other countries confirmed Theiler's findings that fly larvae which have fed upon toxic carcasses are themselves toxic since they retain the preformed toxin. Further evidence of the association of fly larvae with *C. botulinum* type C is attested by the fact that Bengtson (1922) described the prototype from an isolate derived from *Lucilia caesar*. Later she isolated the same type from *Phaenicia sericata*. Other investigators subsequently obtained cultures from many invertebrates. Hobmaier (1932), Quortrup and Sudheimer (1942A), Kalmbach and Gunderson (1934), Coburn and Quortrup (1938), and others used mass cultures of vertebrate and invertebrate tissues to demonstrate the suitability of those substrates for the development of toxin. The two kinds of tissue are probably equivalent [from McHargue as quoted by Birge and Juday (1922)], for the development of cultures of *C. botulinum*.

Normal waterfowl consume animal matter principally in the form of invertebrates (Henderson, 1934; Bent, 1925). Further leads have developed from the fact that invertebrate remains have been found on those relatively rare occasions when food was identifiable in intoxicated ducks (Quortrup and Sudheimer, 1942A; Pullar, 1934; Watson, 1952; Williams, 1941; Coburn and Quortrup, 1938; Kalmbach and Gunderson, 1934).

The findings of these investigators led us to explore the possibilities of individual invertebrate carcasses as foci for the development of toxic cultures of *C. botulinum* type C. Our data can be best presented in tabular summaries.

Tables 1 and 2 contain the data derived from the exposure of media in segments of the environment of the Bear River Refuge in Utah, where botulism has occurred year after year. Open-end glass cylinders, 10 inches in length, were placed in shallow bays

in such a manner that one end was inserted in the mud and the other end projected above the surface. The substrates were immersed in the water enclosed by the cylinders. The data are presented here for the primary purpose of showing that animal tissue (beef liver) is a suitable substrate for cultivation of *C. botulinum* under conditions found in the Refuge. None of the vegetable substrates, including fresh chopped *Salicornia*, and seeds of barley, rice, wheat, and corn yielded toxin in that environment. Since toxin was developed in uninoculated liver tissue as well as in liver tissue inoculated with detoxified spores, it is evident that spores were present in the environment, although botulism was practically nonexistent in the area in those periods.

TABLE 1.—THE DEMONSTRATION OF TOXIN IN CYLINDERS CONTAINING INOCULATED AND UNINOCULATED BEEF LIVER EXPOSED IN ISOLATED SEGMENTS OF THE ENVIRONMENT OF THE BEAR RIVER REFUGE, AUGUST 3, 1953

Tube No.	Inoculated	Day													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Control (no substrate added)	No	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
1 (liver)	No	−	−	−	NC	+	+	+	+	+	−	−	−	−	−	NC
2 "	No	−	−	+	+	+	+	+	+	+	+	+	+	NC	+	NC
3 "	No	−	−	+	+	+	+	+	+	+	NC	−	−	−	−	−
4 "	Yes	−	−	−	+	+	+	+	+	+	−	−	+	−	+	NC
5 "	Yes	−	−	+	+	+	+	+	+	+	+	+	+	+	+	+
6 "	Yes	−	NC	+	+	+	+	+	+	+	NC	−	+	+	NC	−
Water Temp.:																
(Maximum) °F:		x	94	96	x	91	93	94	92	94	92	92	93	x	94	94
(Minimum) °F:		x	51	55	x	60	60	x	52	54	56	66	63	x	60	60

\+ Toxin present. NC Not conclusive.
− Toxin not present. x Data not available.

TABLE 2.—THE DEMONSTRATION OF TOXIN IN CYLINDERS CONTAINING INOCULATED AND UNINOCULATED SUBSTRATES EXPOSED IN ISOLATED SEGMENTS OF THE ENVIRONMENT OF THE BEAR RIVER REFUGE, AUGUST 27, 1953

Tube No.	Inoculated	Day												
		1	2	3	4	5	6	7	8	9	10	11	12	13
Control (no substrate added)	Yes	−	−	−	−	−	−	−	−	−	−	−	−	−
1 (grain barley)	Yes	−	−	−	−	−	−	−	−	−	−	−	−	−
2 (liquid corn steep)	Yes	−	−	−	−	NC	−	−	−	−	−	−	−	−
3 (green salicornia)	Yes	−	−	−	−	−	−	−	−	−	−	−	−	−
4 (grain barley)	Yes	−	−	−	−	−	−	−	−	−	−	−	−	−
5 (liver)	Yes	−	−	+	+	+	+	NC	+	+	+	NC	+	+
6 (duck feathers)	Yes	−	−	−	−	−	−	−	−	−	−	−	−	−
7 (green salicornia)	Yes	NC	−	−	−	−	−	NC	−	−	−	−	−	−
8 (liver)	Yes	−	−	+	+	+	+	+	+	+	NC	+	NC	+
9 (grain rice)*	Yes	x	x	x	x	x	−	−	−	−	−	−	−	−
11 (liver)	No	−	−	+	+	+	NC	NC	+	+	+	+	NC	+
12 (liver)	No	−	−	+	+	NC	NC	−	+	+	NC	−	−	−
Water Temp.:														
(Maximum) °F:		83	82	88	98	90	84	85	84	84	85	84	84	88
(Minimum) °F:		60	57	60	58	59	58	50	48	52	50	54	54	58

* Rice placed in cylinder September 1, 1953.
Symbols explained in Table 1.

The results of these tests and of others from the laboratory reveal that toxin is produced over a wide range of temperature if a suitable medium is present. The very frequent development of toxin in tubes containing liver, irrespective of the status of disease in the ducks on the refuge, is noteworthy since high temperature is frequently considered necessary for the occurrence of an epornitic.

Data demonstrating that intact invertebrate carcasses are suitable substrates for growth of *C. botulinum* type C are presented in Table 3. Some negative results are not recorded because they appear to be the result of failure of the larvae of late instars to ingest spores. Observations relevant to the latter phenomenon are recorded in the reports of the Cooperative Botulism Studies. Other data confirming the fact that high titers of toxin can be generated in invertebrate carcasses are not included because lengthy description of special technics would be involved. It is evident, however, that dead calliphorid maggots and stone-fly nymphs are adequate substrates for toxin production by the *Clostridium*.

In these experiments the living, washed immature instars of insects of two orders were exposed to detoxified spores of a toxigenic strain of *C. botulinum* type C. After a brief period of immersion in a suspension of spores, they were killed with chloroform vapor. Groups of five larvae, nymphs, or pupae were placed in test tubes (Fig. 1) containing 10 ml of distilled water. After variable periods of incubation at 37°C, the insects were removed and triturated in approximately nine volumes of saline. Normal mice and mice protected with specific antitoxin were injected with serial decimal dilutions of the triturates. A sample of the ambient liquid was also titrated in mice.

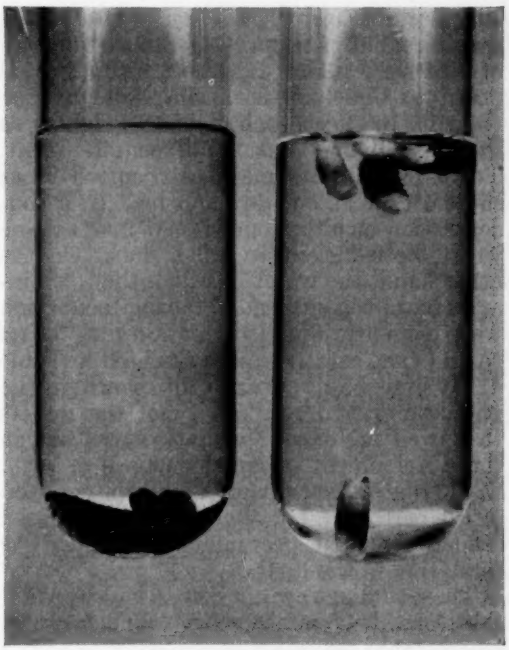

FIG. 1. Typical tubes showing sunken and floating larvae in distilled water.

Carcasses of the calliphorid larvae had a specific gravity of approximately 1, but would usually sink to the bottom of the tube. No provisions were made for anaerobiosis. It was notable that the bodies of the insects

TABLE 3.—THE SUITABILITY OF INSECT CARCASSES AS A MEDIUM FOR TOXIN PRODUCTION BY *C. botulinum* TYPE C

Experiment No.	Species	Stage Infected	Stage Tested	Period of Incubation (days)	Titer of toxin in carcasses (Mouse MLD per 0.1 gm.)
239A3-Y	*Phormia regina*	Larva	Larva	1	10^3
239A3-Z	" "	"	"	2	10^3
239A3-Z-2	" "	"	"	5	10^3
243IC8-2	" "	"	"	4	10^3
244A-4A	*Plecoptera* sp.	Nymphs	"	21	10^3
244A-4D	" "	"	"	8	10^3
244A-5	" "	"	"	2	10^3
260B-12	*Phormia regina*	Larva	Pupa	19	10^4
260E-19	" "	"	"	7	10^4

were suitable for germination of spores and were capable of supporting the metabolism of this very strict anaerobe, although exposed to dissolved or atmospheric oxygen (Fig. 1). In effect, each carcass (weighing as little as 16 mg) was a microenvironment. Toxin formation sometimes occurred in as short a time as one day and reached a concentration such that one gram of insect tissue would be sufficient to kill a duck. On the other hand, the water in which the toxic insects had been suspended during incubation was frequently found to contain little or no toxin (some examples are presented in Table 4). It may be noteworthy in regard to the palatability and availability of the insects that even prolonged incubation resulting in the development of large amounts of toxin would not be accompanied by disintegration of the carcasses, but there was an increased tendency to float, presumably because of gas formation in the bodies.

These findings are consistent with the fact that toxin is so infrequently found in water where ducks become intoxicated. Exceptions may be found in the water and mud immediately under bird carcasses but bird carcasses are not at all essential for the initiation of an epornitic, and it is questionable whether they have an essential role in the continuation of a wave of mortality. One of our associates, C. S. Sperry of the Denver Wildlife Research Laboratory, Fish and Wildlife Service, made this question the subject of considerable study, and his observations were that feeding wild ducks would for some reason carefully avoid bird carcasses at any stage of active decomposition. Maggots feeding in the carcasses were therefore immune to depredations by the ducks. Quortrup and Sudheimer (1942B) noted that larvae were readily eaten when dislodged from the carcass, and that washed larvae seemed to be much more palatable to ducks. It was concluded that larvae dislodged from carcasses by storms could account for appreciable mortality at times. Migration of active prepupae would presumably have the same effect.

Other investigations which are not directly concerned in the concept presented here have shown that the spores of *C. botulinum* type C may be retained by flies through the metamorphoses to, and including, the adult stage, and that adult calliphorids may transmit infection from contaminated to clean media. We have also confirmed the observations of Theiler and others that larvae which have resided in toxic medium will retain toxin both in and on their bodies. Even pupae developed from larvae which had migrated into clean sawdust were found to have toxin adherent to the pupal cases, but not within the bodies. This toxin amounted to about 100 mouse LD_{50} (or the equivalent of about 1/1000 of a toxic dose for a duck). These experiments are related in detail in the cooperative reports.

SUMMARY AND CONCLUSIONS

A practical solution to the problem of botulism in ducks will probably depend upon a more complete explanation of the epizoology of the disease than is available at present. One of the most important unknowns in the epizoology is the medium or media required for growth and toxin production of *C. botulinum* type C. There have been frequent references in reports and in the literature to the effect that large masses of decaying organic matter of either vegetable or animal origin comprise the culture medium

TABLE 4.—A COMPARISON OF TOXIN CONCENTRATIONS IN INVERTEBRATE CARCASSES AND IN THE AMBIENT LIQUID

Experiment No.	Species	Stage	Period of Incubation (days)	Titer in carcass (Mouse MLD per 0.1 gm.)	Titer in Ambient Liquid (Mouse MLD per 0.1 ml.)
239A3-Z	*Phormia regina*	Larva	2	10^3	10^0
239A3-Z-2	" "	"	5	10^3	0
244A-4A	*Plecoptera* sp.	Nymphs	1	10^3	10^0
244A-4D	" "	"	8	10^3	10^1
260B-12	*P. regina*	Pupa	19	10^4	10^1
260E-19	" "	"	7	10^4	0

in which growth of the bacteria occurs. In that concept (which we have labelled the "sludge-bed concept") the concentration of organic matter and kinds of solutes present in waters in epizootic areas have been considered important. The microenvironment concept described in this paper presents an alternative explanation which holds that:

1. *C. botulinum* type C will germinate, reproduce, and synthesize its toxin in small, discrete particulate substances such as invertebrate carcasses.

2. The particulate substances contain within them all of the essentials for metabolism of the bacteria, and in that respect are independent of the ambient medium.

3. The toxin ingested by waterfowl is probably in the bacteria which reside in the particulate substrates, rather than in the form of soluble, freely diffused toxin.

The data presented establish that the carcasses of immature instars of two orders of insects will support growth and toxin production when those carcasses are suspended in distilled water freely exposed to atmospheric and dissolved oxygen. Therefore, the microenvironment hypothesis is a tenable one and justifies field work to determine whether microenvironments are important in the development of epornitics of botulism.

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DEER RANGE APPRAISAL FOR THE MISSOURI OZARKS[1]

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The reduced carrying capacity which results in overbrowsed deer ranges has been well documented in many areas, and the general way in which deer herds overbrowse their food supply is now well understood (Leopold, *et al.*, 1947). But balancing deer herds with their food supply is still a new task in the oak forests of the Ozark region; recognizing overstocked deer ranges here presents some difficulties not generally encountered in northern and western states.

In the Ozark region, the growing season is long, frost-free periods average 180 days, and green herbs are available to deer throughout the year. There are no critical winter deer concentration areas like those encountered in northern deer yards or on the winter range of migratory deer. The problem in the Ozarks is to recognize incipient over-populations of deer in the absence of key areas where browse damage is concentrated and striking, and the objective of this investigation was to study deer food habits in order to discover plants which would be sensitive indicators of incipient over-populations.

Atwood and Steyermark (1937) made preliminary observations on deer food habits in the Ozark region. Dalke (1941) tallied woody plants commonly browsed in Missouri refuges during winter and suggested six woody species which might be important to winter carrying capacity. Dalke and Spencer (1944) reported on destructive overbrowsing where deer were confined in a private game preserve in southern Taney County, Missouri. Recently, Donaldson, *et al.* (1951) listed deer food preferences observed on study plots and recorded differences in pounds of herbage produced inside and outside deer exclosures on the Ozark National Forest in Arkansas; Lindzey (1952) reported on food plants browsed on study plots in southeastern Oklahoma; and Korschgen (1952) analyzed the contents of 270 deer stomachs collected in Missouri.

These investigators have listed a total of 256 plant species utilized by deer and reported that green herbaceous vegetation was eaten throughout the year. Korschgen found oak mast to be the single most important deer food in Missouri, and the other investigators cited above reported the importance of acorns. This contribution of the acorn to deer diet has also been recognized by investigators in southern states (Ruggles, 1938; Ruff, 1938; Pearson, 1943). None of the investigators in the Ozarks, however, suggested deer food plants which could be used as early indicators of overbrowsing.

Procedure

In order to study the year-around pattern of deer food habits, two deer were confined in a 90-acre enclosure in the Clark National Forest, and the food preferences of these animals were observed for one year—February 1949 to January 1950. The conclusions which developed were corroborated and strengthened by further study in areas of greatest deer density in 21 counties of the Missouri Ozarks.

The enclosure was established in typical wooded deer range. It had been logged several times, grazed by free-ranging livestock, and burned repeatedly in past years. This land-use is typical of Ozark forests, and the vegetation here is typical of much of the unfenced forest land in this region.

The 90 acres of the enclosure included parts of two upland ridges, with both north and south slopes, and an upland ravine. Ridges and upper slopes are occupied by a mixture of white, black, and scarlet oaks, shortleaf pine, and Ozark hickory (*Carya*

[1] Contribution from the Missouri Conservation Commission and the Missouri Cooperative Wildlife Research Unit: U. S. Fish and Wildlife Service, Wildlife Management Institute, Missouri Conservation Commission, Edward K. Love Foundation, and University of Missouri cooperating. The initial study was made possible through a fellowship granted by the Edward K. Love Foundation. Subsequent work was done while the author was in the employ of the Missouri Conservation Commission, Pittman-Robertson Project 13-R. I am indebted to Leon K. Hornkohl for helpful suggestions, and to William H. Elder for supervision and editing.

texana), while flowering dogwood and species of blueberry are most common in the understory. In the understory of lower slopes and in the ravine, red maple, black gum, witch-hazel, and spice bush are common. Herbaceous ground flora consists of species commonly found on rocky acid soil in the eastern Ozarks (Steyermark, 1940).

One of the deer in the enclosure, a yearling buck, was used to the presence of humans and could be followed closely in his search for forage. This animal had free rein to use his nose to choose the fruit and fungi, green herbage, and twig tips of his daily diet. Close observation of this foraging deer made possible discovery of food preferences and use of forage which normally goes unseen. The other deer was too elusive to be observed on the brushy terrain.

Judging feeding preferences of deer by observations of an individual deer in an enclosure could be a source of error. However, Nichol (1938) found that, while the amount of food required by bucks or does varied according to the physiological needs of the sexes, the forage preferences of an individual deer closely paralleled the preferences of the herd.

Observations of the browsing deer were made for at least 12 days of each month, March through September, and less frequently during the other months when preferences were changing less rapidly. "Forage-minutes," as commonly used for recording forage preference (Dixon, 1934), was not a practical method for use with this deer because its usual bite-and-skip manner of browsing on the variety of plants in this woodland meant that several species were browsed within any one minute. As the animal foraged, each bite was tallied by species. Later these species were grouped into general forage types and the relative proportions of each type were computed (Fig. 1).

FINDINGS

Green broad-leaved herbaceous plants made up the largest single class of deer food during an eight-months period from March to November, and supplied a large proportion of the deer forage throughout the year. These forbs are chiefly perennials which grow on the rocky uplands in Ozark woodland; Compositae, Umbelliferae, and Leguminosae are characteristic of this kind of deer range. Prominent use of forbs by deer would be a surprise to those who approach deer studies with a woody-twig bias. However,

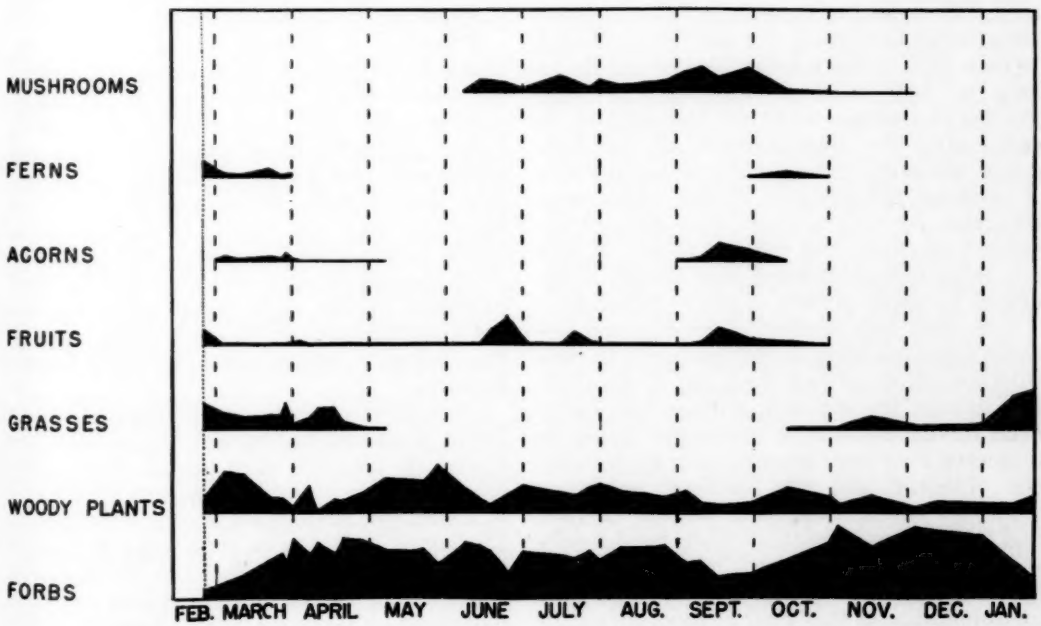

FIG. 1. Relative use of deer foods from February 24, 1949 to January 20, 1950.

forbs generally comprise the most abundant class of vegetation in Ozark forest ground cover (Read, 1951).

Asters and goldenrods are browsed during their growing season and, after the upper portions wither, small basal leaves provide green food throughout the winter.

While forbs were a consistent part of deer diet, there was considerable seasonal variation in the type of food eaten. There were times when grass, shrubs, fungi, fruits, seeds, or acorns were also major food items.

Grasses and grass-like plants supplied the largest proportion of the forage in early spring. Flower buds and twig tips from the woody plants which break dormancy early also were browsed. Over-wintering rosettes of panic grass and sedge, catkins of alder and hazlenut, and the flower buds of spice bush and red maple were among these foods. The expanding buds and young leaves of most other woody species in the enclosure were browsed during a limited period, but decided preferences of deer for foliage of a particular woody species were not found at this season.

It became evident from watching deer that the foliage of some plants ordinarily is eaten for only a short time and not browsed again during the growing season. Less than half of the shrubs and trees browsed during spring were browsed later during the summer. Thirty-four of these were eaten at some time during the spring, but only 14 continued to be a part of the regular deer forage for as long as four months. The early-growing grasses and sedges were not observed to be eaten after the appearance of the inflorescence, although these plants remained green throughout the summer. Plants which were palatable for only a short time did not receive much use, and most evidence of this and other spring browsing was quickly obliterated by rapid growth of the vegetation.

The high palatability of mushrooms became apparent because the deer went to considerable effort to root them out of the duff, and usually the entire mushroom was eaten even though some caps were eight inches in diameter. Few were ignored; only the poisonous *Amanita* and the leathery polypores were not eaten. Following periods of rain and warm, humid weather when mushrooms were especially abundant, they made up about 25 per cent of the daily forage, and an abundance of this kind of food obviously lessened browsing on other vegetation.

Winter deer forage was supplied primarily by acorns, other fruits and seeds, dried leaves, and green forbs, along with aments and twig tips from a few woody plants.

Pussy's-toes, *Antennaria plataginifolia*, was the most widely distributed and abundant of the green forbs in woodland during the winter. Although not used in summer, it was the most commonly eaten green plant in the enclosure during winter. However, it was apparent from watching deer browse, that signs of browsing on *Antennaria* and most of the other over-wintering green plants are obscure. The green forage supplied by these plants is chiefly the small autumn growth hidden in the leaf litter, and leaves are clipped in such a manner that browsing of much of this kind of food cannot be detected.

It was also apparent from watching deer that little winter use is made of deciduous plants. Much of the browsing on these species appeared to be for some part other than the twig. The fruits of coralberry, flower-spikes of fragrant sumac, and catkins of hazelnut appear to be the parts preferred. Supporting twigs sometimes were clipped as the fruits were taken, but deer generally ignored the fibrous twigs of these species as well as the twigs of hardwood sprouts and seedlings which comprise most of the woody understory of the oak-hickory forest type.

Presence or absence of an acorn crop markedly influenced the amount of browsing on other winter foods. In the enclosure, acorns of the 1948 mast crop, a particularly large crop for the black oak group, remained sound and were a part of the deer diet until mid-May of 1949. Well-developed acorns of the 1949 crop were readily eaten when they began falling in mid-August. However, this crop was sparse, and almost none remained available to deer after two months. Following disappearance of the acorn mast, deer in the enclosure browsed pine and cedar foliage heavily.

On a nearby refuge, coralberry and sumac fruits remained unbrowsed throughout the winter of 1948–49 when acorns were abundant, but were entirely consumed by the end of December 1949, when acorns were scarce. Damaging browsing on pine was reported as having occurred in 1944–45, a winter when acorns were scarce, and in a like manner, damaging browsing on pine recurred in 1949–50. In each case, the browse line on pine was

masked by regrowth within two years so that it could not easily be seen. Winter browsing on evergreens, although heavy enough to be damaging during years of mast shortage, does not appear to be a consistent indicator for the detection of early overbrowsing.

While watching deer foraging, it became apparent that some plants were never eaten. A number of species were examined and rejected by the deer in the enclosure, and evidently were consistently unpalatable. The rejections were made after smelling, not by a tasting process like Nichol (1938) reported for the mule deer. Forty-one herbaceous species and 11 woody species were so rejected during the growing season by my captive deer.

Many of these plants of little or no desirability as deer food are widely distributed and occur commonly in the ground flora of the Ozarks: Bracken fern (*Pteridium latiusculum*), big bluestem (*Andropogon Gerardi*), little bluestem (*Andropogon scoparius*), wild oat grass (*Danthonia spicata*), purpletop (*Triodia flava*), Indian grass (*Sorghastrum nutans*), goat's rue (*Tephrosia virginiana*), everlasting (*Gnaphalium obtusifolium*), dittany (*Cunila origanoides*), wild indigo (*Baptisia leucophaea*), red bud (*Cercis canadensis*), flowering dogwood (*Cornus florida*), fragrant sumac (*Rhus aromatica*), and hazelnut (*Corylus americana*). These plants are so abundant that a hillside may be green with their foliage where the palatable plants have been suppressed or eliminated.

The unpalatable plants, along with some species which are only lightly browsed, have remained intact on sites in Ozark deer refuges where preferred forage has been browsed to the point of destruction, and the green aspect of plants of low palatability increases the burden of demonstrating overbrowsing to the public, which does not usually distinguish species.

On Ozark deer range little winter browsing has been found on woody twigs, in spite of close examination of woody plants during four winters under a variety of conditions. Noticeable amounts of browsing on annual twig growth have been observed on only six species, namely: smooth and dwarf sumac, shortleaf pine, red cedar, sassafras, and low blueberry. Pine, cedar, sassafras, and low blueberry were commonly browsed only on those areas which supported the largest herds of deer and under circumstances which indicate that these species rank low in palatability. Not enough of the annual growth of any of the deciduous species has been browsed to affect the vigor of the plant.

Korschgen (1952) supplied additional proof of the relatively light use of woody plants. His analysis showed that by volume cedar supplied only 1.3 per cent, blueberry .5 per cent, and sassafras and pine less than .5 per cent of the contents of 279 stomachs.

As deer densities increase, deer may conceivably utilize more annual twig growth of the deciduous species. However, a shift to heavy browsing on hardwood twigs did not occur on Indian Trail Refuge, in Dent County, where hunters harvested one deer per 30 acres in 1952 or on the Drury Public Hunting Area, in Taney County, where hunters harvested one deer per 10 acres in 1951.

In contrast to the paucity of twig browsing during winter, some species of shrubs and vines were browsed repeatedly during the growing season. These were: New Jersey tea (*Ceanothus americanus*), wild hydrangea (*Hydrangea arborescens*), summer and frost grape (*Vitis cordifolius* and *V. aestivalis*), pasture rose (*Rosa carolina*), poison ivy (*Toxicodendron radicans*), and Virginia creeper (*Parthenocissus quinquefolia*). All were browsed continuously in the enclosure for a period of six months or more from February to December. Because these plants were a part of the palatable deer food for such a long period, they were browsed repeatedly and appeared to be the most likely plants to show damage from repeated deer browsing.

A series of permanent transects was established in Ozark deer refuges in 1950 to study the effect of repeated browsing on three of these shrubby species and on common perennial forbs. Canfield's line intercept technique (1944) was adapted to this study by counting all forbs rooted in a one-foot belt along the transect line and also by plotting the position of nearby shrubs. Records along the transects were made annually during late summer (Table 1).

Common perennials which have basal leaves remaining green during winter and are grazed by deer were tabulated separately from other perennials and unidentified plants. These overwintering plants are species of *Aster, Solidago, Potentilla, Viola, Phlox, Hepatica, Fagaria, Hieracium, Heuchera, Ranunculus,* and *Antennaria.*

TABLE 1.—NUMBER OF FORBS ALONG 1,380 METERS OF PERMANENT TRANSECT, 1950–1953

	1950	1951	1952	1953
Common overwintering perennials	4,337	4,622	3,881	4,377
Per cent change from 1950		+6.6%	−10.5%	+.9%
Other perennials	3,708	4,513	3,839	4,314
Unidentified plants	165	183	135	241
Per cent change from 1950		+21.2	+2.6%	+17.6%

Transects were deliberately located where the heaviest deer browsing could be found, but there were no indications that deer browsing on forbs had been too heavy. Neither the overwintering forbs nor the others show a decrease which can be attributed to over-use by deer. Changes in the numbers of forbs during the four years appear due to differences in the amount and distribution of rainfall during the growing season, and drought during 1952 and 1953 undoubtedly resulted in changes in the number of forbs which masked any minor changes due to deer browsing. While these forbs could, no doubt, be reduced in density if they were browsed frequently and heavily enough, the heaviest deer pressure along transects was not destructive to them.

However, the destructive effects of close deer browsing showed clearly on preferred shrubs. Plants of three shrubby species—New Jersey tea, wild grape, and wild hydrangea—were singled out for close study; 332 individual plants were marked in 1950. By 1953, plants of all three species showed a loss of thrift or death, either of which denotes a shrinking range carrying capacity. Twenty-two per cent of the New Jersey tea plants were dead; closely browsed wild grapes had been trimmed until they were out of reach of deer; and other plants of all three species were dead or suppressed by browsing.

	Maintaining Vigor	Suppressed	Dead
New Jersey tea	118	13	36
Wild grape	43	33	4
Wild hydrangea	54	20	11

These three shrubby species have proved sensitive to repeated browsing and should serve as early indicators of deer browse damage. Close attention to their thrift during the growing season provides the basis for managing deer to prevent more serious overbrowsing of native vegetation.

DISCUSSION

It was apparent from watching deer that food preferences changed with the growth stage of the plant. This change may well be associated with changes in chemical content which occur in growing plants (Gordon and Sampson, 1939). The significance of this can be appreciated when one considers the correlation found between some chemical constituents of plants and deer preference (Mitchell and Hosley, 1936; Reynolds and Sampson, 1943; Swift, 1948). Further use of deer rather than men to select samples for chemical analysis should permit finer correlation between chemical content and selective browsing.

Observations of a feeding deer indicated that a large part of the browsing in this woodland cannot be detected by examining plants on the range. New growth obliterates some signs of browsing. Most of the delicate browsing on aments and overwintering green plants could not be seen; and other foods, such as fungi and fruits, are eaten entirely. The significance of this can be understood when one considers how frequently the extent of deer browsing is considered on evidence of utilization which can be seen at one time on sample plots.

The fact that Ozark deer ordinarily winter on acorns, along with fruits, seeds, flower buds, and green forbs means that the deer manager has no good indicator species on winter range. None of the few woody plants, either deciduous or evergreen, which are browsed in winter will serve as range "keys" in the sense described by Dasmann (1948). Considering the woody species which are browsed, none is at once highly palatable, important in the bulk of the diet, and has enough of the annual growth eaten to serve as an early indicator of an overbrowsed deer range. Eastern red cedar and shortleaf pine have been destructively browsed during winter, but browsing on these two species was heaviest during mast shortages and both ordinarily rank too low in palatability to be regarded as sensitive indicators of range conditions. Winter browsing on other species in

the Ozarks either must go undetected or is not generally damaging. This situation is in marked contrast to other regions where deer are normally twig-browsers during winter and woody species are sensitive indicators of range carrying capacity.

Early indications of overbrowsing can be recognized by observation of the extent of use of those shrubs which are browsed for a long period during the growing season. Three of these preferred summer browse plants—New Jersey tea, wild grape, and wild hydrangea—have been overbrowsed to the point of suppression and death and, therefore, appear to be the most sensitive indicators of range trend in the Missouri Ozarks.

Ruff has stated that browsing on summer forage on the Pisgah range in the southern Appalachians, when a large number of plant species were available, was a more sensitive indicator of deer range conditions than was the winter browsing on a relatively few evergreen species. Probably this is a general concept, applicable to other southern hardwood areas as well as the Pisgah range and the Ozarks.

SUMMARY

Food habits of a deer confined in a 90-acre sample of range were studied intensively throughout one year. Conclusions reached during this study were supported by observations in areas of highest density in the Missouri Ozarks.

The pattern of deer browsing in Ozark woodland had the following outstanding features: 1) green forbs supplied the major part of deer food through the period from March to November and were an important part of deer diet throughout the year; 2) grasses, shrubs, fungi, fruits, seeds, and acorns were important seasonally; 3) a number of plants were consistently unpalatable and others were palatable for only a short time during the growing season.

Little winter use was made of deciduous woody twigs, and evergreens were so low in palatability that these types were not good indicators for determining the condition of deer range during winter.

Shrubs which were palatable for a long period during the growing season appear to be the most sensitive indicator plants to show destructive overbrowsing. Three of these—New Jersey tea, wild hydrangea, and wild grape were browsed to the point of destruction on the same areas where forbs were not clearly affected by over-use.

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FOOD HABITS OF MARTEN IN INTERIOR ALASKA AND THEIR SIGNIFICANCE [1]

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In interior Alaska, the food habits of marten (*Martes americana actuosa* Osgood) were found to be intimately associated with its movements and other factors related to its distribution and abundance. A review of the findings seems pertinent because of their implications in management, and because the findings appear to apply to marten in other regions.

Several publications provide valuable comparative information on food habits of marten or sable. Microtine rodents were found to be the most important food item of marten in British Columbia (Cowan and Mackay, 1950), and of sable on the Shantar Islands (Dulkiet, 1929), in the Sajan Mountains of Siberia (Kozhantschikov, 1930), on Kamchatka (Malaise, 1929), and in the Ural Mountains (Raevsky, 1938). Squirrels were found to be the most important food of marten in Montana (Marshall, 1946), and in Washington (Newby, 1951), although Newby found that insects formed the most important food in summer. Lagomorphs were relatively unimportant except in Montana where Marshall (*loc. cit.*) found that they constituted 9 per cent of the diet. Table 1 compares the results of these studies and the present Alaskan study.

Food habits of marten in interior Alaska are most similar to those reported for Asiatic species. This similarity is not surprising, for both faunal and floral elements of the habitats are also similar. In Alaska, microtines, mostly *Cleithrionomys rutilus* and *Microtus* spp., were the most important food, comprising 74 per cent of the diet in summer and 68 per cent in winter (Table 2). Berries (blueberries, crowberries and bearberries) were second in importance, forming 18 per cent of the food in summer and 9 per cent in winter. Berries were chiefly important in late summer and in fall, and at that time exceeded mice in importance. Avian foods, grouse in winter and young of all birds in summer, comprised 8 per cent of the summer diet and 19 per cent in the winter. The varying hare and the red squirrel appeared only in winter and formed one and two per cent, respectively, of the total food. These last proportions may be low for interior Alaska as a whole, however, because both squirrels and hares were relatively scarce in the Minchumina area from which a large part of the food habits material was collected.

A few items which might have been expected in the diet were conspicuous by their absence. Among these were shrews (*Sorex*

[1] This paper reports part of a study made by Lensink in partial fulfillment of the M. S. degree at the University of Alaska. Skoog performed the food habits analyses. Buckley directed the research.

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spp.), and low-bush cranberries, both of which are common in interior Alaska. Cowan and Mackay (1951) and Newby (1951) also noted the rarity of shrews in the food of marten, and attributed the lack to the strong smell emitted by the musk glands; conversely, however, captive marten held by Remington (1952) accepted shrews. Cran-

TABLE 1.—SUMMER AND WINTER FOODS OF MARTEN EXPRESSED AS PERCENT OF FREQUENCY OCCURRENCE

	ALASKA[a]		BRIT. COL.[b]		GR. SHANTAR IS.[c]	MONTANA[d]	WASHINGTON[e]	
	Summer	Winter	Summer	Winter	Winter	Winter	Summer	Winter
Microtines	74	68	59.0	79.9	71.7	14	13.4	27.4
Squirrels	..	2	12.9	4.8	7.9	59	9.6	40.5
Shrews	..	..	2.0	0.9	2.0	..	..	..
Lagomorphs	..	1	2.0	4.8	..	9	5.2	2.7
Birds	8	19	5.9	0.9	5.9	7	3.0	8.1
Insects	..	..	7.9	..	..	1	54.7	..
Berries	18	9	5.9	3.8	0.7	..	8.2	2.7
Other	..	1[f]	..	..	11.8	10	..	..

[a] Summer foods based on 469 items in 374 scats; winter foods on 107 items in 28 scats and 64 digestive tracts.
[b] Summer foods based on 202 items in 112 scats and 3 stomachs; winter foods on 104 items in 85 scats (Cowan and Mackay, 1950).
[c] Winter foods based on 152 items (Dulkeit, 1929).
[d] Winter foods only based on 77 items in 64 scats (Marshall, 1946).
[e] Summer foods based on 78 scats and one stomach; winter foods on 17 scats and 16 stomachs (Newby, 1951).
[f] Item not listed is caribou (obtained from carrion). Debris is not included in the calculations.

TABLE 2—OCCURRENCE OF FOOD ITEMS IN SCATS AND DIGESTIVE TRACTS OF MARTEN

Item	SUMMER[a] 374 Specimens; 469 Items		WINTER[b] 92 Specimens; 107 Items		TOTAL 466 Specimens; 576 Items	
	Times Occurring	Per cent of 469 Items	Times Occurring	Per cent of 107 Items	Times Occurring	Per cent of 576 Items
Clethrionomys or *Microtus*	283	60	53	50	336	58
Meadow mouse, *Microtus* spp.	54	11	8	7	62	11
Red-backed mouse, *Clethrionomys rutilus*	8	2	12	11	20	3
Brown lemming, *Lemmus trimucronatus*	3	1	..	..	3	1
Red squirrel, *Tamiasciurus hudsonicus*	..	..	2	2	2	T
Snowshoe hare, *Lepus americanus*	..	..	1	1	1	T
Caribou, *Rangifer arcticus* (carrion)	..	..	1	1	1	T
Unidentified birds	35	7	17	16	52	9
Spruce grouse, *Canachites canadensis*	1	T	3	3	4	1
TOTAL ANIMAL FOOD	384	81	97	91	481	83
Blueberry, *Vaccinium uliginosum*	78	17	10	9	88	15
Crowberry, *Empetrum nigrum*	4	1	..	..	4	1
Bearberry, *Arctostaphylos uva-ursi*	3	1	..	..	3	1
TOTAL PLANT FOOD	85	19	10	9	95	17
TOTAL	469	100	107	100	576	100

[a] June, July, August.
[b] October, November, December, May.

berries were found commonly in marten scats collected in British Columbia by Cowan and Mackay, (*loc. cit.*).

Studies of the food habits of marten which have been reported in the literature and the results of the present investigation indicate that the food habits of marten are governed chiefly by the availability of the various foods. The flexibility of the marten's diet is further indicated by the wide range of foods accepted by captive animals. During the present study, live-trapped marten readily accepted bread, candy, cheese, jam, and peanut butter. Similarly, Remington (1952) reported that two captive young marten ate pancakes, gravy, shrews, raisins, ham, cereal, fish, lettuce, spathetti, bread, and celery.

Observations of animals which were live-trapped in the present study also indicated the tremendously important psychological role that food-getting has in the marten's activities. Edible baits were always utilized and food was readily accepted from the fingers of the trapper, even when the marten were still in the trap. On one occasion, a female was given a candy bar when released. She carried it to a distance of about 10 yards from the trap and stopped to eat in full view of the trapper. In another instance, an animal which had become thirsty while in the live-trap dug into the moss to obtain water as soon as it was released. Tracks of several animals indicated that normal hunting activities were begun almost immediately after release from traps.

Evidently fear, anger, and discomfort are forgotten in the drive to obtain food. Marten held for a short time in cages were quarrelsome and viciously attacked any object held to the cage. When a spoonful of jam was held to the cage, the marten seized it as before, but on discovering the apparently pleasant taste, released the spoon to eat the jam. Later it was found that even when marten were held by the neck, sometimes almost being strangled, they would cease struggling in order to lick jam from a spoon.

A considerable volume of information indicates the relationship of food abundance to the marten's movements and choice of cover. Dulkiet (1929), on the basis of a four-year study of sable on Greater Shantar Island, concluded that the size of the "hunting plot" (home range) was primarily dependent on the food supply, although other factors such as convenience, number of enemies, and competitors were also of influence. Although the winter range of sable varied from about 2 to 8 square miles or even 11.5 square miles in exceptional cases, individual sable remained on areas of less than 0.5 square mile and in one instance only 0.06 square mile when food was abundant. Kozhantschikov (1930) found that the winter range of sable in the Sajan Mountains varied from about 1 to 6 square miles, but concluded that "The size depends on the forest and on the topography. The number of species and individuals of birds and mammals are directly proportional to these factors, and hence the quantity of food." Marshall (1942) found that marten in Montana and Idaho also spent considerable time in a relatively small area when food was abundant, and concluded that food conditions may well govern its ecological requirements. Yeager (1950) attributed the increase in the proportion of females harvested late in the season, at least in part, to greater movements caused by the increased food demands of pregnant females. However, our data indicate that females utilize a smaller range than do males or immature animals, independent of season.

In Alaska it is not uncommon to find marten remaining for several days in a very small area. Repeated observations indicate that available food, such as a particularly lush berry patch or a choice bit of carrion, serves to hold the marten until the food is exhausted. Furthermore, when food is ubiquitously abundant, as during the berry season of late summer, marten movements are greatly reduced. This was reflected in our success in live-trapping, which was greatest when food was least abundant and *vice versa*.

Newby (1951) describes a seasonal, vertical migration of marten in the Cascade Mountains from summer ranges at elevations between 4,000 and 5,000 feet to winter ranges below 3,400 feet. Similarly, vertical movements of marten have been noted in southeastern Alaska by trappers and by Agents of the Fish and Wildlife Service. Although Newby does not clearly indicate the cause of the seasonal movement, it seems likely that it is due to seasonal variations in availability of food at different elevations. In southeastern Alaska, variation in abundance of food is certainly a factor because excessive snowfall in the mountains makes

food there much less accessible than on beaches, where high tides not only wash the snow away, but constantly replenish the supply of marine food. Thus, marten trapping in southeastern Alaska is concentrated near the beaches.

The implications of the marten's food habits in its management are clearly evident when it is considered that the success of trapping widely dispersed animals such as the marten, especially in areas of low trapping intensity such as interior Alaska, is dependent to a large extent on the movements of that animal. Thus, other things being equal, success in trapping marten is inversely proportional to the availability of food, since marten movements are greatest when food is least available. The decrease in the marten harvest in interior Alaska in 1952–53 seems at least partly attributable to the unusually light snow cover and the consequent ease with which marten could obtain food.

Factors, other than food supply, that affect marten movements are sex and age of the animal, and weather. Yeager (1950) has shown, and our data corroborate, that males and juvenile females tend to move greater distances than adult females; and, we have evidence that marten movements tend to decrease in wet weather and in extreme cold.

Cyclic tendencies of marten and their possible relationship to the relative abundance of prey species have been discussed by Elton (1942:273), and by Seton (1929:492). Elton describes a three- to five-year cycle based on records of the Moravian missions in Labrador, and Seton an eight- to ten-year cycle based on Hudson's Bay Company records from the boreal forest of Canada. Elton (1942) has shown that colored foxes fluctuate in the same fashion, *i.e.* with a three- to five-year periodicity in the tundra areas of Labrador and an eight- to ten-year periodicity in boreal regions. He ascribes these differing periodicities to the food base in the respective areas, *viz.* lemmings and voles in tundra regions and hares in forested regions.

We might postulate a similar dependence for marten, were it not for the fact that no study to date has shown the hare to constitute any considerable part of the marten's diet (Table 1). Be that as it may, variations in food abundance, especially when food is scarce, probably affect the population level. The plasticity of the marten's food habits precludes extensive losses from starvation; thus, changes in population levels are probably attributable to altered reproductive success.

Natural fluctuations of the marten population in Alaska have been so obscured by trapping regulations that harvest records give no clue to the causes of the fluctuations. The Alaskan harvest of 1952–1953, however, emphasized the complexity of the problem. There was a decrease in the harvest, probably caused in part by decreased movement resulting from a relative increase in availability of food. Other data, however, indicate that lowered productivity had caused the decrease: in the previous harvest 56 per cent of 143 animals were immature, but in the 1952–1953 harvest only 36 per cent of 155 animals were immature. Either or both factors may be operative, but distinguishing the two is difficult because sex and age ratios in the marten harvest are almost certainly affected by changes in the relative movements of the animals.

In summary, it is emphasized that a marten's food habits may vary with the habitat in which it exists. Changes in abundance or availability of food may be reflected strongly in the marten's movements, its productivity, and its choice of habitat. Thus, food supply should be taken into account in the analysis of data pertaining to any of these elements of the marten's ecology.

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EFFECTS OF HAIL STORMS ON WATERFOWL POPULATIONS IN ALBERTA, CANADA—1953

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INTRODUCTION

The Alberta prairies and parklands form an important part of one of the greatest grain belts in the world, and of one of the greatest waterfowl producing areas in North America. These prairies are characterized by rich soils, gentle terrain, and a well distributed seasonal precipitation. As with growers of grain all over the world, the Alberta farmer must contend with age-old problems of excessive moisture in some years and drought in others, with frosts in spring or autumn and with damage by insects and rusts throughout the summer. Waterfowl populations are also subjected to, and their production influenced by, excesses or deficiencies of moisture, by late or early fall snows or periods of low temperature, by diseases and predation and the progress of the agricultural season in early spring. To these problems must be added another serious factor, of great importance to farmers and of growing concern to waterfowl biologists, the occurrence and the severity of summer hail storms. Due to the atmospheric conditions which make hail storms possible, it follows that this type of storm is most severe and most widespread in years when average precipitation is normal or above normal. The summer of 1953 was no exception. It became one of the most disastrous hail years in the history of the province of Alberta, the worst in fact since 1927.

METHODS

For the past seven years (1947–1953), a cooperative waterfowl breeding ground survey has been conducted in the prairie provinces of Canada. In Alberta, this work is carried on from May until August by ground and aerial crews of the Canadian Wildlife Service, the Alberta Game Branch, Ducks Unlimited (Canada) and the U. S. Fish and Wildlife Service. Information is gathered for the purpose of measuring changes in waterfowl breeding population indices, surface and sub-soil water conditions, ecological aspects of the waterfowl habitats, phenological progress of the breeding season, nesting and hatching success and the effects of agricultural practices on the breeding activities and production of waterfowl. Intensive

ground study areas are utilized as a method of measuring specific populations, population movements, the effects of predation, disease and other factors working for or against the waterfowl in the area under study. Data gathered on these areas are also used in conjunction with those obtained by aerial surveys of both the prairies and parklands. The aerial surveys take the form of east-west transects, one-quarter mile in width, which extend from the foothills of the Rockies to the Saskatchewan border. On these transects water areas and waterfowl are tallied, the latter by sex and species. This survey is made in the month of May. During July a second aerial survey of these same transects is flown to obtain the same type of data, to which is added a count of the waterfowl broods. Wherever possible broods are recorded by numbers of individuals in the brood and by age class.

Ground studies of hail damage in the Vermilion district were made by Messrs. H. R. Webster, and W. G. Smith, Canadian Wildlife Service. Aerial surveys of hail damage caused by the two major storms were made by Messrs. G. H. Jensen and A. G. Smith, U. S. Fish and Wildlife Service.

METEOROLOGICAL CONDITIONS

To summarize briefly the weather conditions prior to and during the 1953 hail season, the reports of the Canadian Department of Transport, Meteorological Division for the period April through August 1953 were used. Some of the coldest weather in the past 70 years was experienced in southern Alberta in April with precipitation two to three times above normal. Early May was warm and dry but from late May through June and July, temperatures were below normal and precipitation was considerably above normal, excesses to 200 per cent being registered in some southern areas. August brought a return to more normal conditions of temperature and precipitation except in the hail areas.

The so-called hail season in Alberta extends from July 1 to August 15. During 1953, it began in mid-June and persisted until September. Normally, hail damage is reasonably spotty and the degree of damage varies widely. In 1953, on the other hand, damage was both intensive and extensive throughout the prairies and parklands. The Alberta Hail Insurance Board released figures to the "Calgary Herald" to the effect that unlike many hail seasons, this one was noted for the fact that in most cases where crop-damage did occur, it ranged from 75 to 100 per cent.

AERIAL ASPECTS OF A PARKLAND HAIL STORM

On July 14, 1953, a very severe hail storm originating a few miles southwest of Delburne, Alberta, beat a swath in a northeasterly direction from its point of origin to Viking, Mannville, Clandonald and the North Saskatchewan River. In a strip averaging 5 miles in width and approximately 140 miles long (700 square miles), this storm, accompanied by winds which at times and in some places reached 75 miles per hour and deposited hail-stones larger than golf balls, devastated a strip across the parklands which brought destruction to grain crops, trees, buildings, livestock and wildlife. This particular storm passed through one of the intensive ground study areas in the Vermilion district where it was possible to make a detailed study of its effects on the waterfowl and their habitats.

This particular storm occurred two days prior to the July aerial survey of the parklands. During this survey the transects bisected the path of the storm on each of the ten parkland transects. In fact the most southerly parkland transect passed over the approximate point of origin of this storm. Aerially it presented a picture of destruction which was so graphic as to warrant further study of its effects on the waterfowl resident on the area. From the air it appeared as a seared strip of land where no green vegetation remained. Leaves and small branches were stripped from the trees; grass, grain, gardens, all had turned brown. No waterfowl of any kind were counted on any of the ten locations where the aerial transects crossed the path of the storm. In other words, ten strips five miles in length flown across the storm path netted not a single adult or juvenile duck.

In attempting to evaluate the damage caused by this storm, consideration has been given to the fact that its path extended from the southwestern to the northeastern boundaries of the parkland vegetative stratum. Assuming that its destructive force was applied homogeneously across the parklands, aerial parkland population and production

data were utilized in calculating damage. By way of further explanation, it should be noted that the waterfowl aerial transects were established as a statistically random sample of the various vegetative strata found in Alberta.

In July an average of 14.29 water areas per square mile was found in the parklands. The area of destruction in this storm was 700 square miles in extent. Thus about 10,000 water areas were blanketed by this one hail storm. As there were roughly 370,000 water areas in the parklands, according to the water area index for July, nearly 3 per cent of all parkland waterfowl habitats were affected.

The parkland aerial waterfowl breeding population index in May was 16.42 pairs or 32.84 ducks per square mile. This means that approximately 11,500 pairs or 23,000 ducks were resident on the storm-affected strip. The July survey indicated a brood index of 3.3 broods per square mile in the parklands and a brood average of 5.71 ducklings per brood. In other words, some 2,310 broods composed of 13,190 ducklings were also resident on this area. By adding these figures from the May and July aerial data, a total loss of approximately 23,000 adults and 13,190 juveniles or 36,190 waterfowl, exclusive of coots, results.

These figures are considered to represent minimum losses for the following reasons: (1) Because of the variation in the width of the path of the storm, the 700 square mile area is a minimum figure. (2) It is known that the aerial observations of waterfowl populations in parkland habitats result in population indices which are considerably lower than the true population. In every instance where comparisons have been made between aerial and ground counts of waterfowl in the parklands of Alberta during the past several years, ground observers count more than twice the number of adults and broods observed from the air. The reason for this is obvious when one considers the density of the vegetation in parkland waterfowl habitats and the speed and time element involved in aerial observations. However as a population index rather than a true population figure is the present goal, estimates of populations based on index figures, would be lower than actual total numbers. (3) Environmental conditions were such as to prevent a 100 per cent loss of waterfowl in all areas. But again, because total mortality figures are based on population indices rather than true total populations, this discrepancy between a total loss and a small percent of survival would be more than compensated for. (4) By mid-July the greater percentage of the male waterfowl population in Alberta has ceased to attend the females and has congregated on moulting areas. Some moulting lakes are very large, some relatively small. Both types are distributed throughout the 700 square miles covered by this storm, i.e. Buffalo Lake, Wavy Lake, Thomas Lake and scores of smaller lakes too large to be classed as potholes and too small to have been named. Thus all types of waterfowl habitats as well as waterfowl in various states of phenological development were struck by this storm.

Therefore, a mortality of 36,190 waterfowl may be considered as the minimum figure to represent losses by this single parkland hail storm. Further evidence to support higher mortality figures will be presented later in the discussion of the ground study of hail effects on an intensive study area.

AERIAL ASPECTS OF A PRAIRIE HAIL STORM

It is true that the area affected by the storm of July 14 is a relatively small proportion of the entire parklands and that the waterfowl killed were also a small fraction of the entire parkland population. However, in attempting to calculate the damage caused by this one storm where crop damage was estimated to be 100 per cent, one is confronted with the more serious fact that this was no isolated whim of the weather.

On July 18, another severe hail storm covering an even greater area struck the grasslands. Originating about five miles northwest of the town of Balzac, which is located about five miles north of Calgary, it beat a path diagonally across the province in a southeasterly direction through Strathmore, Gleichen, Brooks and thence across the prairies to Irvine near the Saskatchewan border. This storm averaged twelve miles in width and damaged an area 200 miles in length. Strangely enough it skipped several areas after it had passed Strathmore. Within the center of the storm, a width of about five miles where the damage was 100 per cent to grain crops, it extended from its point of origin in a continuous strip for fifty-two miles

to the town of Gleichen. From this point on its movement was more erratic and less damaging. No attempt will be made to evaluate the effects on waterfowl over this latter portion of its path. The area of heavy damage, however, blanketed a 260-square-mile segment of the prairies in the district where the heaviest concentrations of breeding waterfowl in Alberta were observed in 1953. As the path of this storm so closely approximates the May and July transects through the same area, utilization was made of water and population data for this specific region, rather than those for the prairie as a whole.

Water and population indices for this district indicate a breeding population of 46.02 pairs or 92.04 ducks, 34.05 water areas, and 2.81 broods per square mile with a brood average of 5.47 ducklings per brood. Thus, on 8853 water areas, 23,930 adult and 4,000 juvenile ducks were resident at the time of this devastating storm, a total of 27,930 waterfowl.

The two storms discussed above were possibly the most widespread in their destructive force of any occurring during the summer. It was also possible to make aerial and ground observations in those instances, where it was not in others. However, many other hail storms of like nature covering fewer linear miles but of equally destructive force swept across portions of the prairies and parklands from mid-June until late August. No attempts to estimate damage in other parts of the province have been made though at least three other hail storms of especially destructive force are known to have hit the extreme southern prairie (40 linear miles), the northern prairie (65 linear miles) and the parklands (50 linear miles). Scores of others on which no data are available, except for newspaper accounts, had unknown effects on the waterfowl populations.

GROUND ASPECTS OF A PARKLAND HAIL STORM

One intensive study area in the parklands was in the direct path of the July 14 storm. As two waterfowl biologists were engaged in field work on this area throughout the summer, it was possible to make detailed observations of the effects of the storm within a short time after the damage had occurred. This area, one-eighth mile in width, is located on the west side of the north-south highway which passes through the town of Vermilion. It extends approximately 33 miles north and 23 miles south of the town. The hail belt bisected this transect obliquely from the southwest to the northeast about thirteen miles north of Vermilion. The width of the hail-affected area was 8.8 miles, divided into a northern zone of moderate to light damage, 0.5 miles in width, a center zone of heavy damage, 6.0 miles in width, and a southern zone of moderate to light damage, 2.3 miles in width. Although the destruction of crops within the zone of heavy damage was generally considered to be 100 per cent, there was visual evidence that the intensity of the storm varied across this and to a greater extent across the zones of lighter damage. This was especially true of the southern zone which was five times as wide as the northern one.

Ground observations of the hail destruction presented a picture of real devastation. Vegetation was shredded beyond recognition and beaten into the earth. Trees were bare of leaves and small branches, the bark on the southwest side of the trees had been torn away or deeply gouged by hail stones. Aquatic emergent vegetation was reduced to an unrecognizable pulp surrounding the potholes. Where it occurred as emergent growth in the water, it was broken and beaten under the surface. This opened up water areas whose surfaces had been choked by sedges, grasses and cat-tails since early June.

Song-birds, hawks, owls, crows, grouse, coots, grebes and ducks, both adult and juvenile, were wiped out. Adult ducks of all species as well as their young littered the potholes and lakes in the storm's path. These soon collected in windrows along the shores as the winds pushed their floating bodies into the debris-lined edges of the ponds. This quickly rid the surface of the dead bodies and hid the effects on the waterfowl population to a cursory observer. In cases where dense stands of emergent growth occurred throughout the water area, the bodies of these birds became entangled in the broken stems of these plants.

When hail has occurred on other occasions but to a lesser degree of intensity, emergent cover usually offered sufficient protection to reduce losses. In this particular storm, the destruction was so complete that even the lush growths of five-foot cat-tails could only

be recognized by the shredded stubs which stuck above the earth. A day or two of sunshine following the storm cured all of this finely ground plant material, changing it from green to brown.

In estimating the population of the affected areas at the time of the storm, certain mechanical difficulties of censusing must be taken into consideration and some assumptions must be made. The most important point around which our conclusions hinge is the assumption that the breeding population was reasonably static during the period from July 6th and July 16th. The former date represents the time when the last population check was made prior to the storm, the latter date the population check after the storm. From population data gathered before and after the storm, and from banding operations throughout the period, the evidence points to a rather static population. As we know that both adult and juvenile ducks move freely from one area to another during this period of the year, we have assumed that birds leaving the study area would tend to equal those moving into it.

The waterfowl population on the area just prior to the storm was estimated by using the brood, its species, age class and average size for the entire study area, as a reliable unit of measurement. When a brood had been recorded as to species and age but an incomplete count of its numbers had been made, the average size of the age-class for that species for the study area as a whole was utilized. In several instances complete broods were found dead within a limited area, some of which had not been recorded in the regular counts or they had hatched after the July 6th count. Dead ducklings (one or more) which did not correspond to prior broods recorded were considered to represent a brood. Banding operations were used to supplement or substantiate this data wherever possible. Thus a population of 19 broods or 142 ducklings and 33 adult ducks were estimated as being resident on the hail area prior to the storm (Table 1).

Although the storm struck on July 14th, it was not known that it had crossed the transect until the regular population check on July 16th. This delay of one day may have introduced a bias in the data as the result of the normal movement of birds into the area from unaffected locations nearby. Each area was checked at least twice by two men using a Brittany Spaniel. With the trees denuded of leaves and the emergent aquatic vegetation along the shorelines cut-off at or just above the water or ground, and with water levels unseasonably high, the improved visibility made for an even more accurate count of live birds. In the total area of the hail strip, a post-storm population of 8 broods of 44 ducklings and 19 adults were counted (Table 2). In the area where heavy damage had occurred, only 2 adults and 5 young remained alive. This is a loss of 93.4

TABLE 1.—ESTIMATED POPULATION AT TIME OF STORM ON TOTAL HAIL STRIP

Degree of damage	Extent in miles	Pond number	Total adults	Ducks with broods	Number of broods	Total Ducklings
L		27	4	4	4	30
I		30	3	1	1	11
G	2.3	31	2	..	..	..
H		32	..	..	..	..
T		33	..	..	..	..
Totals		5 ponds	9	5	5	41
H		34	8	5	5	32
E		47	..	..	..	..
A	6.0	48	5	5	5	39
V		56	7	2	2	15
Y						
Totals		4 ponds	20	12	12	86
LIGHT	0.5	59	4	2	2	15
Grand Totals	8.8	10 ponds	33	19	19	142

TABLE 2.—ESTIMATED POPULATION AFTER STORM ON TOTAL HAIL STRIP

Degree of damage	Extent in miles	Pond number	Total adults	Ducks with broods	Number of broods	Total Ducklings
L		27	4	4	4	30
I		30	1	..	..	..
G	2.3	31	6	..	..	..
H		32	1	..	..	..
T		33	2	..	..	..
Totals		5 ponds	14	4	4	30
H		34	1	..	2	5
E		47	1	..	..	..
A	6.0	48	..	..	..	..
V		56	..	..	..	..
Y						
Totals		4 ponds	2	..	2	5
LIGHT	0.5	59	3	2	2	9
Grand Totals	8.8	10 ponds	19	6	8	44

Percent loss on total hail area: 64.0%.
Percent loss on heavy hail area: 93.4%.

per cent from the original population of 106 ducks. Of those ducks still living, one adult and one Class III duckling were both found to have broken scapulae.

Each water area was carefully checked in order to obtain an accurate count of dead ducks. However, the task of sifting so much plant debris for birds entangled in the water as well as those caught on the shore made a complete and minute coverage impossible. Nevertheless, within the zone of heaviest damage, the bodies of 7 adult and 34 juvenile ducks and 3 adult and 3 juvenile coots were recovered.

Although population and production records were kept on the coot observed on the study area, no effort has been made here to evaluate the mortality on this species. It is significant, however, that in the area of heavy damage, the coot population was substantially reduced and both adult and young were found dead. From general observations of the results of the storm on areas adjoining the study area, where there were heavy populations of both ducks and coots, the coots survived the storm better than did the ducks.

In addition to the very apparent effect on the vegetation within the hail belt, the severity of the storm was as evident when dead birds were examined for injuries causing death. Skulls were found crushed, eyes were protruding or missing. Mandibles of many were all but torn off, legs and wings were broken and deep bruises occurred on the backs of adult ducks, while partially feathered or downy young were found with the skin on the back severely torn and bruised. Of interest for comparison with the effects of this storm on waterfowl, a 600-pound sow and several calves were killed by hail in the immediate vicinity, and autos that were caught out in the open were so badly dented that the bodies were beyond repair.

For the past three years comparisons have been made between the waterfowl population counts of aerial and ground crews in sample areas in the parklands where dense vegetation hampers visibility. Though many more checks of a similar nature have yet to be made throughout this vegetative stratum, it is significant that on every occasion thus far, the aerial waterfowl index of population is always about 30 per cent of the figure obtained by the ground observers. Though the ground figure would still not represent a complete count of the waterfowl population present, it would, nonetheless, be a closer approximation of it than would the figure obtained from the air.

If a 70 per cent variability between ground and air population counts is used as a means of refining the figures of waterfowl mortality from hail damage in the July 14th storm,

startling facts present themselves. There is a strong possibility that in this single storm there may have been 76,700 adult and 44,000 juvenile waterfowl killed, a total of 120,700.

CONCLUSION

Any factor acting upon waterfowl populations in an area which can decimate that population by a minimum of 64,120 or a maximum of 148,630 in two days by two storms must be considered of major importance. Fortunately hail seasons such as that of 1953 occur infrequently and are relatively confined in their effects. Nevertheless, Alberta does provide hundreds of thousands of waterfowl to the Pacific and Central Flyways and when one considers the gamut of other mortality factors which these birds have to run, losses of such magnitude are of major significance, even though they may occur sporadically. As nothing can be done to prevent a hail storm, to direct or deflect its path, or to protect the waterfowl in its path, we can only try to evaluate the damage occurring to these species after it has occurred, using these data in the manipulation of the harvest of the species involved.

As this series of storms swept an area where it was possible to survey the damage from both the air and the ground shortly after it had occurred, it is felt that this information may be of some value to persons interested in waterfowl management.

Several factors must be taken into consideration in evaluating the effects of hail on waterfowl populations. Among these are wind velocities, size of hail-stones, duration of the storm, phenological development of the species involved, size of the birds affected and their habitat preferences. Hail damage experts are able to estimate the total damage to a crop of grain after a hail storm. In the future, after many more observations have been made as to the effects of storms of varying degrees of intensity on waterfowl populations, it may be possible to establish a standard unit of measurement whereby waterfowl mortality from hail storms may be estimated.

SUMMARY

1. On July 14, 1953 a devastating hail storm swept 700 square miles of the parklands in Alberta destroying an estimated 36,000 to 120,000 adult and juvenile waterfowl.

2. On July 18, 1953 another destructive hail storm wiped out approximately 28,000 adult and juvenile waterfowl in 260 square miles of prairies in Alberta.

3. Aerial and ground study of the areas of destruction made possible the correlation of air-ground data from breeding population, brood and water count indices to evaluate the damage caused by these storms.

4. Because of the great number of severe hail storms during the summer of 1953, whose effects were not studied, it is probable that over 148,000 waterfowl were lost to hail in this one province during a two-and-one-half month period.

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LOSS OF GAME FISH IN RELATION TO PHYSICAL CHARACTERISTICS OF IRRIGATION-CANAL INTAKES[1]

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Introduction

Numerous efforts have been made in the United States to prevent loss of fish in irrigation diversions. One of the earliest attempts was on Caledonia Creek, New York in 1865 (Leitritz, 1952). Probably the most intensive effort has been in California (Wales, 1948; Leitritz, 1952) where a large number of ditches have been screened.

A fish-screening policy was adopted in Montana in 1893 but was discontinued in 1897 (Clothier, 1953a) and maintenance of screens was abandoned by the Fish and Game Department in 1942 (Montana Fish and Game Department, 1942). Most of the work has been directed toward development of fish screens which are known to be effective, but cost of installation and maintenance has limited their use.

Clothier (1953a) reported a variation in fish loss between irrigation diversions of the West Gallatin River and found much diversity in the physical characteristics of the canals. The present study, conducted from June through October in 1951 and 1952, deals with the relationship between physical characteristics of canal intakes and fish loss. If a relationship exists, then feasible alterations of existing and proposed diversions might reduce fish losses. The U. S. Fish and Wildlife Service and the Montana Fish and Game Department (1952) in a joint report on the Pishkun Supply Canal, suggested that design, location, and operation of canal headings may have a direct effect on fish loss.

Grateful acknowledgment is due to Dr. C. J. D. Brown who directed the project and aided in the preparation of the manuscript and to Mr. William Clothier for his assistance in the field. Thanks are also due to Mr. Melvin Papke for information on diversion flows and to the ranchers of Gallatin Valley for their cooperation. Dr. Bernard Ostle supervised the statistical analysis of the data. Financial assistance was furnished by the Montana Fish and Game Department under the Federal Aid to Fish Restoration Act (Project number F-3-R).

Description of Study Area

A rather complete description of the West Gallatin River and some of the diversions was given by Clothier (1953a). Of the 52 diversions on the West Gallatin, nine (Fig. 1)

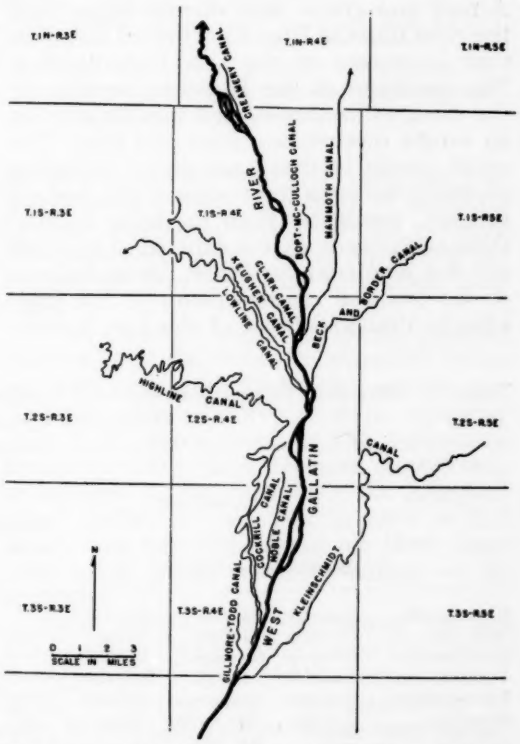

FIG. 1. A 20-mile section of the West Gallatin River, Montana, showing the locations of the canals studied.

were selected for study in 1951. These were as follows: Kleinschmidt, High Line, Low

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Line, Keughen, Beck and Border, Creamery, Clark, Gillmore-Todd and Cockrill (Table 1).

The Kleinschmidt canal was the largest of the diversions studied in 1951 and carried 151 cubic feet of irrigation water at decreed right. This canal, located at the upstream end of the study area (Fig. 1) takes water from a straight section of the river near the mouth of Gallatin Canyon. The canal runs parallel with the river for at least one-half mile downstream and, although a concrete apron extends across the river from the headgate, for the placement of a diversion dam, no dam was operated during the period of the study. The headgate is directly on the river, framed in concrete and regulated by a wooden gate operated vertically by a turnstile.

The High Line and Low Line canals carry 148 cubic feet per second and are located on a bend of the river. Each forms an acute angle with the river at the point of diversion. A rock and gravel dam diverts water from the river into the High Line but no diversion dam is present at the Low Line heading. The headgate of the Highline canal is on the river while that of the Low Line is on an intake downstream from the river. The canal intake is that part of an irrigation diversion between the river and the first, or primary, headgate. Both headgate foundations and frames are constructed of concrete and are regulated vertically. Measurements of the physical characteristics of the High Line in 1951 and those of the Low Line in 1952 were not used since sharp reductions in rate of flow may have influenced gamefish loss (Clothier, 1953a).

The Keughen canal (70 cfs) is located on a bend of the river and leaves it at an angle. The runoff in 1952 altered the river flow past the diversion resulting in considerable change in some of the physical characteristics including angle of the diversion with the river. A concrete apron extends across the river at the headgate but no diversion dam was operated during the period of the study. The headgate is on the river, framed in concrete and regulated vertically.

The Beck and Border canal (50 cfs) removes water from a straight section of the river and leaves it at an angle. The concrete headgate is downstream from the river on an intake and is regulated vertically.

The Creamery canal (20 cfs) is located at the downstream end of the study area (Fig. 1) and takes water from a bend of the river. As a result of bridge construction near the head of this canal in 1952, some of its physical characteristics were altered before they could be measured. The ditch forms an angle with the river and has no diversion dam at its head. The headgate is downstream, framed in concrete, and flow into the diversion is regulated horizontally by standing planks on end from side to side across the headgate opening.

The Clark diversion (16 cfs) takes water from a straight section of the river and runs parallel with it. No diversion dam was oper-

TABLE 1.—PHYSICAL CHARACTERISTICS OF INTAKES OF 12 IRRIGATION CANALS ON THE WEST GALLATIN RIVER, MONTANA, IN 1951 AND 1952

DIVERSION	HEADGATE				PHYSICAL CHARACTERISTICS								
	Material	Location	Kind	Diversion dam	Relation of river flow	Velocity (ft/sec)	Volume (cfs)	Gradient (ft/mi)	Width (ft)	Depth (ft)	Cover (percent)	Angle of canal 1951	Angle of canal 1952
Kleinschmidt	Concrete	On river	Vertical	...	Straight	3.37	151	4.3	20.0	3.6	68	..	0
High Line	Concrete	On river	Vertical	Yes	Bend	4.60	148	19.8	18.8	2.5	33	..	53
Low Line	Concrete	Downstream	Vertical	...	Bend	....	148	....	....	...	..	33	..
Keughen	Concrete	On river	Vertical	...	Bend	3.09	70	2.1	25.0	2.1	1	75	60
Beck & Border	Concrete	Downstream	Vertical	Yes	Straight	2.37	50	5.5	47.5	1.2	9	..	30
Creamery	Concrete	Downstream	Horizontal	No	Bend	1.78	20	....	37.5	1.1	16	46	31
Clark	Concrete	O.r. 1951 Ds. 1952	Vertical	No	Straight	4.91	16	15.3	11.3	1.2	24	0	0
Gillmore-Todd	Concrete	On river	Vertical	No	Straight	....	15	....	....	...	..	0	..
Cockrill	Wood	On river	Vertical	No	Straight	2.47	6	1.5	19.0	1.3	36	0	0
Mammoth	Concrete	On river	Vertical	Yes	Bend	3.61	74	15.3	11.3	3.0	2	..	40
Noble	Wood	On river	Vertical	Yes	Bend	2.55	23	3.2	25.0	1.2	52	..	42
Bopt-McCulloch	Concrete	On river	Vertical	Yes	Bend	2.56	12	3.2	26.0	1.8	0	..	30

ated during the period of the study. During 1952, the first headgate was inundated and destroyed by the runoff; thus, in 1951, the headgate was directly on the river while in 1952, the second headgate became the primary water-flow regulator and was downstream. The headgate is framed in concrete and is manipulated vertically.

The Gillmore-Todd canal (15 cfs) is located on a straight section of the river and runs parallel with it. The headgate is on the river, constructed of concrete, and regulated vertically. During the summer of 1952, access to this canal was withdrawn. As a result it was impossible to census the diversion and it was eliminated from the 1952 comparisons.

The smallest canal studied was the Cockrill which carries 6 cubic feet per second at decreed right. Occasionally a rock and gravel diversion dam is constructed at its head but none was present during the study period. This canal removes water from and runs parallel with a straight section of the river. The headgate is on the river, is constructed entirely of wood, and is manipulated vertically.

In 1952, the Mammoth, Noble, and Bopt-McCulloch diversions were added to the sample, making a total of 11 canals which were studied.

The Mammoth ditch (74 cfs) is located on a side-channel of the river on a bend and forms an angle with it. A concrete and plank diversion dam was operated in 1952 and completely dewatered the river channel below the headgate during late summer. The headgate is on the river, framed with concrete and regulated vertically.

The Noble ditch (23 cfs) leaves a bend of the river at an angle and a rock and gravel dam diverts water into it. The headgate is on the river, is built of wood, and is manipulated vertically.

The Bopt-McCulloch diversion (12 cfs) is located on a side-channel of the river. It takes water from and forms an angle with a bend of the river. A rock and gravel diversion dam is present and the concrete headgate, which is regulated vertically, is directly on the river.

TABLE 2.—LOSS OF GAME FISH IN DIFFERENT CANALS FOR 1951 AND 1952 (1951 DATA FROM CLOTHIER, 1953A)

Diversion	Estimated legal-game fish loss 1951		Estimated game-fish loss 1952		
			Legal-sized		Undersized
	No.	Lb.	No.	Lb.	No.
Kleinschmidt	560*	227*	11	3.5	11
High Line	61**	23**	21	11.1	14
Low Line	132	71	8**	1.6**	28**
Keughen	167	44	13	10.4	34
Beck & Border	368*	176*	22	10.0	44
Creamery	44	33	0	0.0	79
Clark	77	20	19	5.9	34
Gillmore-Todd	22	6	..	..	..
Cockrill	16	5	10	3.7	22
Mammoth	..	..	51	22.4	44
Noble	..	..	7	2.5	14
Bopt-McCulloch	..	..	14	3.3	76

* Loss influenced by creeks entering canals.
** Sharp reductions in rate of flow before sampling may have influenced loss.

METHODS

Stations were established at comparable locations near the head of each canal intake, and velocities, widths, depths, and gradients were measured (Table 2). A detailed map of the intake and adjacent river area was prepared for each ditch. The types of materials used in the construction of the primary headgates and the method of regulating the volume of flow into the diversions were noted.

Clothier (1953b) reported that the greatest movement of fish into irrigation diversions occurred during the high-water period. Accordingly, intake velocities were measured July 7–9 (near the end of the high-water period for 1952). A water-level station was established in the river near the Keughen canal intake. A variation in level of 8.5 inches was recorded during the three days required to obtain velocity readings at all stations.

Water velocity was determined by the float method (Welch, 1948) since high water levels prevented the use of the current meter. A 25- to 50-foot range was established at each intake and surface floats were timed from the upper to the lower end of the range. Three readings were taken at each station and the average velocity determined. A comparison was made between velocities taken by the float method and by a Leupold and Stevens "Midget Current Meter" when

water levels permitted. In these comparisons, the float method yielded higher velocities in all cases with a percentage difference which ranged from 10 at the lower velocities to 23 at the higher; the average difference was 16.6 per cent.

Information on volume of flow was secured from the River Commissioner and the decreed rights were used for the study of the relationship between loss of fish and volume of flow. Gradients were determined at each canal intake with a hand level.

In 1952, average widths and depths across the canal intakes were obtained as soon as water levels permitted (July 24–31). The water-level fluctuation at the Keughen station during this period was three inches. Three measurements of width were taken at each station and the average determined. Depths were obtained by measuring the distance from the water surface to the canal bottom at each one-foot interval of width and the average determined by totalling the readings and dividing by one more than the number of observations.

Plane-table maps were completed during the periods June 20–August 21, 1951 and July 23–August 15, 1952. In 1951, the angle between each intake and the river was determined. In 1952, each canal intake and the river adjacent to the diversion from 150 feet downstream to 300 feet upstream was mapped in detail and measurements of physical characteristics obtained. The physical characteristics determined were as follows: locations of primary headgates, location of the canal intakes in relation to the direction of river flow, angle between the intake and river, bottom types, bottom contours, bank cover, and location of diversion dams if present.

Clothier (1953a) estimated the loss of legal-sized game fish (total length, seven inches or over) in certain diversions of the West Gallatin River for 1951. His figures (Table 2) were used for the study of the relationship between loss of fish and the various physical characteristics of the intakes for that year. He found the greatest number of fish in the first half-mile of canal. In 1952, 900 feet of each canal immediately downstream from the headgate was sampled by an alternating-current "shocker." Each area was divided into three sections by the use of blocking nets for convenience in sampling. All fish collected were counted, weighed, and measured and the results were used for the 1952 comparisons. Very few fish smaller than three inches were included because the meshes (one-half inch stretch) were too large to retain them. All diversions were sampled between July 14 and August 8 except the High Line and Low Line canals which were sampled August 21 and September 13 respectively.

Loss of Fish in Relation to Physical Characteristics of Canal Intakes

An attempt was made to determine what relationship, if any, existed between fish loss and the various physical characteristics of canal intakes. The characteristics of the headgates considered were location, construction, and method of manipulation. The characteristics of the intakes were velocity of flow, volume of flow, gradient, width, depth, location in relation to river flow, angle with river, diversion dams, bottom types, and cover.

Headgates: The primary headgates of some canals are located directly on the river while in others, they are at varying distances downstream. The loss of legal-sized game fish in 1951 averaged 18.8 pounds (70.5 fish) in the Keughen, Clark, Gillmore-Todd and Cockrill diversions which had headgates on the river and 52.0 pounds (88.0 fish) in the Low Line and Creamery canals which had headgates downstream. Other ditches studied were excluded from this comparison since loss was known to be influenced by water manipulations or other causes (Clothier, 1953a). In 1952, the loss of legal-sized fish averaged 7.1 pounds (15.9 fish) in those diversions which have headgates on the river and 8.0 pounds (20.5 fish) in those which have headgates downstream. The loss of undersized game fish averaged 36.8 fish in the former and 39.0 in the latter. The loss in the Low Line ditch was not used in the 1952 comparisons since water manipulations may have influenced it (Clothier, 1953a).

In 1951, the loss of legal-sized game fish averaged 34.8 pounds (88.4 fish) in the diversions with headgates constructed of concrete and was 5 pounds (16.0 fish) in the Cockrill canal which has a headgate built of wood. In 1952, the loss of legal-sized fish averaged 8.3 pounds (18.9 fish) in the diversions with concrete headgates and 3.1 pounds (8.5 fish) in the Noble and Cockrill canals which have

wooden headgates. The loss of undersized game fish averaged 42.0 fish in the former group and 18.0 in the latter.

Water flow into each of the diversions studied is regulated by vertical manipulation of a wooden gate in the headgate opening with the exception of one canal which is regulated by placing planks on end from side to side across the opening. In 1951, the loss of legal-sized game fish averaged 34.6 pounds (82.8 fish) in the ditches which have vertically manipulated headgates and was 33 pounds (44 fish) in the Creamery canal which has a horizontally manipulated headgate. In 1952, the loss of legal-sized fish averaged 8.1 pounds (18.7 fish) in the diversions which have vertically manipulated headgates while there was no loss of legal-sized fish in the Creamery canal which has a horizontally manipulated headgate. The loss of undersized fish averaged 32.6 fish in the former and was 79.0 in the latter.

Velocity, volume, and gradient: A comparison was made between loss of fish in those diversions which had above average and those which had below average velocity, volume, and gradient at the intake (Table 1). In 1952, the average velocity in all canal intakes was 3.13 feet per second. The loss of legal-sized game fish averaged 10.7 pounds (25.5 fish) in the ditches which had velocities above average and 5.0 pounds (11.0 fish) in the canals which had velocities below average. The loss of undersized game fish averaged 24.8 fish in the former and 44.8 in the latter.

In 1951, the average volume of flow at the headgates was 45.8 cubic feet per second. The loss of legal-sized game fish averaged 57.5 pounds (150.0 fish) in the Low Line and Keughen canals which had above-average volumes and 16.0 pounds (39.8 fish) in the Creamery, Clark, Gillmore-Todd, and Cockrill diversions which had volumes below average. In 1952, the average volume was 57.0 cubic feet per second. The loss of legal-sized fish averaged 11.0 pounds (24.0 fish) in the Kleinschmidt, High Line, Mammoth, and Keughen canals which had volumes above average and 4.2 pounds (12.0 fish) in the Beck and Border, Noble, Creamery, Clark, Bopt-McCulloch, and Cockrill ditches which had volumes below average. There was an average loss of 25.8 undersized fish in the former and 44.8 in the latter.

The gradients of all canal intakes averaged 7.8 feet per mile. The loss of legal-sized fish averaged 13.1 pounds (30.3 fish) in the diversions which had gradients above average and 5.6 pounds (12.8 fish) in those which had gradients below average. The average number of undersized fish lost was 30.7 in the former and 33.5 in the latter. The gradient of the Creamery intake was not included because of alteration which resulted from highway construction.

Width and depth: A comparison of fish loss in the diversions in relation to the widths and depths across the canal intakes was made in 1952 (Table 1). The average width across all canal intakes was 24.1 feet. There was an average loss of 5.2 pounds (11.2 fish) of legal-sized game fish in the diversions which have intakes wider than average and one of 9.3 pounds (22.4 fish) in those which have intakes narrower than average. The average number of undersized fish lost was 49.4 in the former and 25.0 in the latter.

The average depth across all canal intakes was 1.9 feet. The loss of legal-sized fish averaged 11.9 pounds (24.0 fish) in those diversions which have intakes deeper than average and 4.2 pounds (12.0 fish) in those which have intakes shallower than average. The numbers of undersized fish lost averaged 25.8 in the former and 44.8 in the latter.

Location in relation to river flow: Some intakes are located on bends and others on straight sections of the river and comparison of fish loss was made between those two types of diversions. In 1951, the loss of legal-sized game fish averaged 49.3 pounds (114.3 fish) in the ditches which have intakes on river bends and 10.3 pounds (38.3 fish) in those which have intakes on straightaways. In 1952, the legal loss averaged 8.3 pounds (17.7 fish) in those diversions which have intakes on bends and 5.8 pounds (15.5 fish) in those which have intakes on straightaways. The loss of undersized fish averaged 43.5 fish in the former and 27.8 in the latter.

Angle with river: Some canal intakes are parallel with the river from their origin to at least 150 feet downstream while others leave the river at an angle (Table 1). Those which are parallel are referred to as forming an angle of zero degrees with the river. A comparison of fish loss was made between diversions which form above-average angles and those which form below average angles

with the river. In 1951, the average angle between the intake and the river for all canals was 25.7 degrees. The loss of legal-sized game fish averaged 49.3 pounds (114.3 fish) in the diversions which form greater-than-average angles with the river and 10.3 pounds (38.3 fish) in those which form less-than-average angles. In 1952, the average angle between the intakes and the river was 28.6 degrees. The loss of legal-sized fish averaged 8.5 pounds (18.3 fish) in the diversions which form greater-than-average angles with the river and 4.4 pounds (13.3 fish) in the ones which form less-than-average angles. The loss of undersized fish averaged 43.6 fish in the former and 22.3 in the latter.

Diversion dams: Most of the canals have diversion dams constructed of either rock or concrete and which extend out into the river to divert water into the intake. In 1952, a comparison of fish loss was made between ditches with diversion dams at the intake and those without. The Kleinschmidt and Keughen canals have concrete diversion dams which were not operated and they were excluded from the comparison. The loss of legal-sized game fish averaged 9.9 pounds (23.0 fish) in the ditches which have diversion dams and 3.2 pounds (9.7 fish) in the canals which do not have diversion dams. The loss of undersized fish averaged 38.4 fish in the former and 45.0 in the latter.

Bottom types and cover: Some intakes and the adjacent river bottoms were predominantly silt and sand while others were gravel and rubble. In 1952, a comparison of fish loss in the diversions was made in relation to these two bottom types. An average of 4.3 pounds (11.5 fish) of legal game fish were lost in the diversions which have silt and sand bottoms in the intake and adjacent river as compared with 9.3 pounds (20.3 fish) in those which have bottoms of gravel and rubble. The loss of undersized fish averaged 55.3 fish in the former and 25.2 in the latter.

Cover was classified as pools, overhanging brush, and undercut banks and the area of each type was determined for the area of the intake and the adjacent river (Table 1). The total percentage of cover was obtained by adding the number of square feet of area occupied by water three feet or more in depth, of the area covered by overhanging brush, and of the area covered by overhanging bank, and then dividing by the number of square feet of the total water area. In 1952, a comparison of fish loss was made between diversions having above-average and those having below-average cover on the intakes and adjacent river areas; the average was 24.1 per cent. The loss of legal-sized game fish averaged 5.2 pounds (12.3 fish) in those diversions which have above-average cover and 8.7 pounds (19.8 fish) in those which have below-average cover. There was an average loss of 15.3 undersized fish in the former and 46.8 in the latter.

DISCUSSION

An attempt was made to correlate the loss of legal-sized game fish with the various physical characteristics of canal intakes. The loss of undersized game fish was not considered because the method of sampling did not permit a true estimate of their numbers. The ditches studied were few in number but they are believed to be representative of the irrigation diversions of the West Gallatin River, Montana.

While some of the characteristics of headgates, such as location, construction, and manipulation, could be correlated with fish loss, this information is not considered reliable because other factors may have a greater influence. Among these other factors are the volume of flow, the amount of water diverted into the ditch as compared to the amount retained by the river, and the location of intakes in relation to river flow.

The loss of legal-sized game fish was proportional to the volume of flow in the ditches except for the Kleinschmidt canal. To determine the significance of this relationship, the regression of loss of fish on volume of flow was computed and found to be, $Y = 10.2 + 0.429X$ and, $Y = 3.0 + 0.067X$ for the 1951 and 1952 comparisons respectively, where Y = loss of legal-sized game fish (pounds), and X = volume of flow of canal (cfs). In both cases, the regression was significant at $P \leq 0.05$. therefore; it appears that a reasonably high degree of linear association exists between loss of legal-sized game fish and volume of flow in the diversions.

The measurements for the Mammoth and Kleinschmidt canals were not included in the regression computations. The Mammoth ditch is located on a lateral branch of the West Gallatin River and from early in the irrigation season until the headgate is closed in the autumn, approximately July 1 to

October 15, all but a negligible amount of water is diverted from the river into the canal. In 1952, the Mammoth ditch sustained the highest loss of legal-sized game fish and it is believed that it was the result of this dewatering practice. Although the Kleinschmidt Canal had the largest volume of flow of any of the ditches studied, it sustained a very low fish loss in 1952. This diversion is on the upper part of the study area (Fig. 1) and the river adjacent to the intake is not subject to dewatering. The small loss in the canal may well be accounted for by the fact that the intake is also on a straight section of the river and apparently few fish are present in this area.

The linear regressions of fish loss against velocity, gradient, depth, or width did not prove to be significant. It is therefore assumed that these physical characteristics influence fish loss in irrigation diversions only when in combination.

In considering canal intakes in relation to river flow, the greatest loss of legal-sized game fish was sustained by those on river bends but, in 1951, these canals (Low Line, Keughen and Creamery) also had higher volumes of flow. However, if the Low Line and Keughen diversions were excluded from the comparison, so the canals with intakes located on river bends would be more comparable in volume of flow to those with intakes located on straightaways, the loss in the former would still be almost three times that in the latter. In 1952, the average volume of flow for the diversions with intakes on river bends was practically the same as for those with intakes on straightaways. The loss of legal-sized game fish was highest in canals with intakes on river bends.

The regressions derived from the data on fish loss against the angle of the intake with the river was not significant. The information from this study does not support the inference that the angle by which the intake leaves the river has any influence on legal-sized game fish loss.

When comparing losses of legal-sized game fish in canals which have diversion dams with those in canals which do not, the former group of canals sustained the greater loss; however, this higher loss is thought to result from other factors, particularly volume of flow.

In considering the loss of fish in relation to types of bottom in the intakes and adjacent river areas, the diversions which have bottoms of gravel and rubble sustained a higher loss than those with silt and sand bottoms. Again, this higher loss is thought to be a result of other factors including volume of flow.

Regarding the effect of cover at the intakes and the adjacent river areas, the regression of fish loss on the three types of cover, individually and collectively, was tested and found to be not significant. It is thought that cover may not affect the loss of legal-sized game fish other than whatever influence it may exert in combination with location in relation to river flow.

SUMMARY

1. Fish loss was determined and the various physical characteristics of the canal intakes and headgates were evaluated during the summers of 1951 and 1952 for 12 irrigation diversions of the West Gallatin River, Montana.

2. The physical characteristics considered were: headgate location, construction, and manipulation; intake velocity of flow, volume of flow, gradient, width, depth, and angle with the river; location of intakes in relation to river flow, diversion dams, bottom types, cover, and amount of water diverted in relation to the amount retained by the river.

3. No correlation was apparent between loss of legal-sized game fish and location, construction, or manipulation of headgates.

4. The linear regression of loss of legal-sized game fish on velocity, gradient, width, or depth of intakes did not prove significant by the analysis of variance test.

5. The regression of loss of legal-sized game fish on the angle of the intake with the river or amount of cover at the intake or adjacent river areas did not prove significant.

6. Bottom types in the intake and adjacent river areas or the existence of diversion dams at the intake apparently had no observable influence on the loss of legal-sized game fish.

7. Loss of legal-sized game fish was highest in canals with the higher volumes of flow and in those with intakes located on river bends.

8. The highest loss of legal-sized fish in 1952 occurred in a canal into which all but a negligible amount of water was diverted from the river channel on which it was located.

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AERIAL RECONNAISSANCE OF MOOSE IN SUMMER

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During the past decade wildlife management technicians have successfully employed aerial reconnaissance to determine population trends in many game species. In North America this method has been used chiefly for censusing deer, elk, mountain sheep, pronghorn antelope, bison, and waterfowl.

Each census method is not without its particular limitations. The aerial survey has been criticized mainly on the basis of its applicability to censusing deer where its use has been restricted primarily to rather open, flat terrain or deciduous forests during the winter months (Trippensee, 1948). Nevertheless, the aerial survey is superior to all types of ground survey in the rapidity with which a small number of observers are able to cover large areas, frequently quite isolated, even within weeks of an anticipated hunting season. Adams (1940) suggested the aerial strip census for moose which method has been employed with reasonable success in mountainous country of British Columbia (Edwards, 1952), on Isle Royale (Aldous and Krefting, 1946), Ontario (de Vos and Armstrong, 1954), and elsewhere.

The present paper is a report on an experimental aerial survey of moose (*Alces americana*) conducted in central Ontario during the summer of 1949 by the Fish and Wildlife Division of the Ontario Department of Lands and Forests. The purpose of this survey was three-fold: (1) to determine the feasibility of an aerial reconnaissance in summer, (2) to check the accuracy of aerial observations by means of concomitant aerial photography, and (3) to compare "strip" censusing with "water-course" censusing.

METHODS

Two study areas were selected in heavily forested "lake country" due east of Lake Superior where moose were known to occur in considerable abundance (Figure 1). One area was located in the Chapleau Game Preserve (designated the "Chapleau" area) and the other in the Lake Superior Provincial Park (designated the "Superior" area). In both areas local differences in elevation were never more than 100 feet. The dominant tree species of the mature forest are balsam fir (*Abes balsamea*), spruce (*Picea mariana* and *P. canadensis*), jack pine (*Pinus banksiana*), and white birch (*Betula alba*). The Chapleau area was less than half the size of the Superior area and of somewhat flatter terrain (Table 1). In addition it should be noted that the Chapleau area was censused by following a series of interconnected lakes and streams forming a sort of meandering transect, whereas the Superior area was divided into a series of

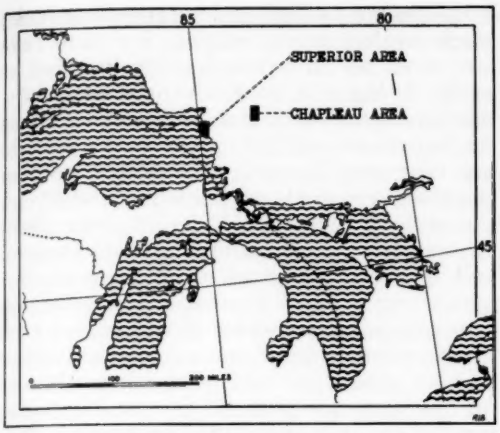


FIG. 1. Location of two census areas in central Ontario.

parallel east-west flight lines, spaced so as to effect 100 per cent coverage of the entire study area (Figure 2).

Fields of view were marked off with relation to the wing struts of the airplane so that at a given altitude two observers (in addition to the pilot) could observe a fixed width of ground on either side of the airplane. With eyes directed only to the water areas, large sections were scrutinized with comparative ease, ignoring extensive wooded areas where moose would necessarily go undetected. On sighting a moose or its trail the pilot would maneuver the airplane from the cruising altitude to an elevation of 300 to 400 feet in order to better view and photograph the animal, after which the cruising altitude was regained.

The field crew consisted of three men: pilot, photographer, and recorder. The photographer and recorder observed on opposite sides of the airplane. The pilot also assisted in spotting animals whenever possible. The author served as recorder, plotting the course of the plane and pin-pointing every animal observed on a field map of the area. Other pertinent information such as weather

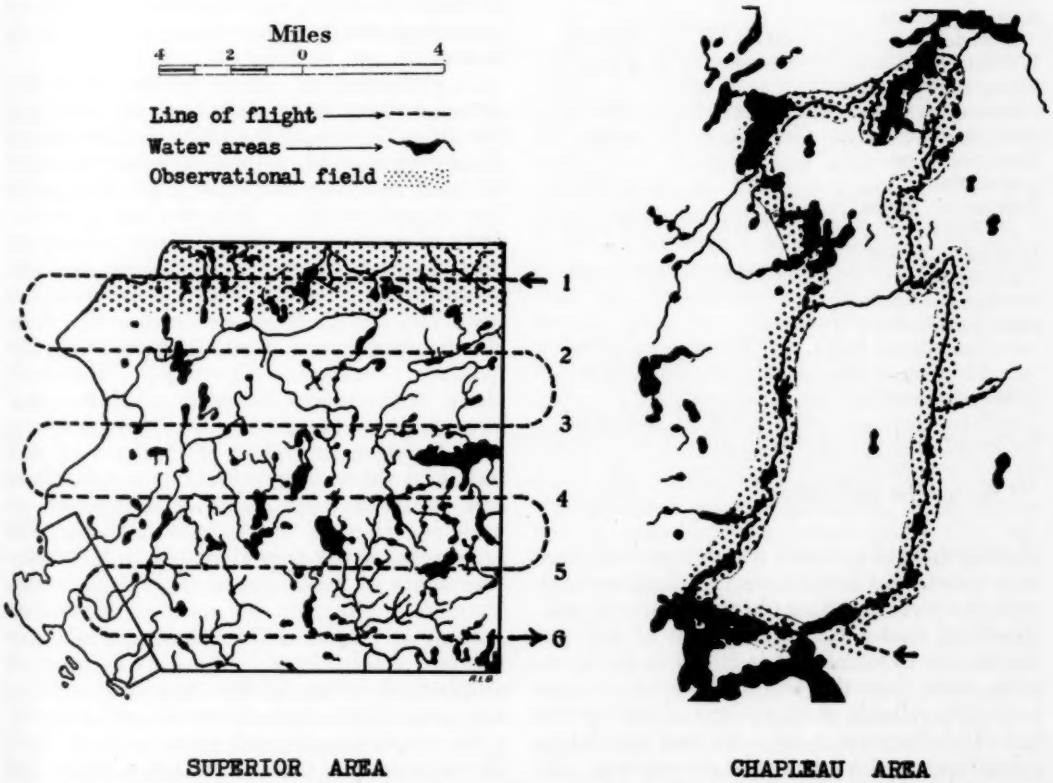


FIG. 2. Semi-diagrammatic maps of census areas showing major water areas, flight lines, and approximate field of observation (shaded portion).

conditions, altitude, age and sex, was noted.

Flights were made over each area on clear days or approximately three times a week during the period July 6–31, 1949. The airplane was a 145-h.p. Aeronca Sedan fitted with pontoons. The right-hand door was removed to facilitate photography. A Keystone aerial camera was equipped with a 15-inch f. 5.6 Wollensac telephoto lens, Type F-8. Exposures were made at 1/300 second at f. 5.6 on 5″ x 7″ Eastman Super-XX panchromatic film.

RESULTS

Data for the two study areas are presented in Table 1. From an analysis of 122 usable photographs of moose it was determined that only three sight records were in disagreement with the corresponding photographic records. Realizing that a hasty judgment of sex was frequently necessary, it is felt that these results show that the aerial observations can be highly reliable at elevations of 300 to 400 feet. It is important to note that sex determination was based on the presence or absence of antlers. An obvious limitation to the data on sex arises from the fact that it is impossible to distinguish a yearling male, whose antlers would consist of a mere button, from an antlerless female, yearling or adult. Using the methods here described, this limitation could not be overcome. Thus the figures on sex ratio given in Table 1 do not represent the real sex ratio. Young of the year were distinguishable from adults on the basis of body size and coat color. Only two calves were seen during the entire survey and on both occasions they were accompanied by a cow. A greater concentration of moose is indicated for the Chapleau area where, according to one calculation, there was one moose per 3.1 square miles, whereas for the Superior area there was one moose per 4.0 square miles. This apparent difference in density of moose between the two areas is possibly a reflection in part of an increase in difficulty of spotting animals in the water from a cruising altitude of 1300 feet (Superior area). Undoubtedly there are other factors which may affect the number of moose observed in water areas. An analysis of flight records, too extensive to present here, suggests the operation of the following factors:

TABLE 1.—DATA ON AN AERIAL SURVEY OF MOOSE IN TWO AREAS OF CENTRAL ONTARIO, JULY 6–31, 1949

	Chapleau area	Superior area
Size (square miles)..	47	117
Average cruising altitude.....	400 ft.	1300 ft.
Width of transect...	1/2 mile	2 miles
Flying time per flight (hours).....	0.5 to 1.5	1 to 2
Total no. flights.....	10	12
Total no. moose observed.....	75	129
Average no. moose per flight.....	7.5 [A]	10.8 [A]
Largest no. moose per flight.....	15 [B]	29 [B]
Average no. square miles per moose:		
Using figure [A]	6.3	10.8
Using figure [B]	3.1	4.0
Total no. moose by sex*.....	49♂ : 29♀	61♂ : 61♀
Sex ratio*.....	1.7♂ : 1.0♀	1.0♂ : 1.0♀

* See text for clarification.

1. Temperature. More moose were observed on very warm days than on cool days. On July 17, one of the hottest days during the census period, a total of 29 moose were counted over the Superior area, this being the largest number recorded on any one flight. On the same day a forest ranger reported seeing seven bull moose in one lake at one time. The moose probably enter the water to obtain food and also relief from biting insects and heat. Moose were frequently observed wallowing in the mud along the shallow margins of lakes and streams.

2. Relative humidity. The effect of this factor on the activity of moose is difficult to ascertain but it probably acts through an intensification of the effects of heat. The proximity of the Superior area to the foggy east shore of Lake Superior might possibly have some effect on the number of animals present in the coastal lakes and streams nearby. As indicated above, the greatest number of moose in the Superior area on any one flight was observed on July 17 while approximately 50 miles east of Lake Superior in the Chapleau area slightly less than the average number of moose were observed on this same hot day. On July 17

the Chapleau area was surveyed from 11:35 a.m. to 12:10 p.m., the Superior area from 1:12 p.m. to 2:26 p.m.

3. Time of day. There is some evidence to suggest that fewer moose were observed in the early morning flights as compared to mid-day and late afternoon flights. As with the relative humidity factor considered above, the effect of time of day is probably a function of the temperature.

4. Season. Although this survey was conducted over a relatively short period (July 6–31), more moose were observed in the latter half of this period. Some of the warmest weather arrived during the latter half of July but also the observers were considerably more experienced at that time.

5. Type of habitat. The aerial photographs have been analyzed according to habitat type and it was found that approximately 85 per cent of the moose were observed in shallow lakes and only 15 per cent in streams. If these figures are significant it would strongly suggest that the moose prefer a shallow lake habitat where the yellow water lily (*Nuphar* sp.) is often abundant.

6. Frightening of animals. On three occasions animals were seen to flee to cover on approach of the airplane. In general, however, little difficulty was experienced with fright. On many occasions it was necessary to resort to "buzzing" the moose in order to induce "posing" with head above water. But even in spite of our efforts, over 52 per cent of the "defective" photographs of moose were so classified because the head was submerged. Thus it seems unlikely that the sound or sight of the airplane frightened many moose from water areas.

A great deal of the accuracy of an aerial survey depends on quick spotting of an animal from relatively high cruising altitudes. The following "indicators" were effective on clear days from altitudes as high as 1300 feet (see Figure 3).

1. Muddy water. This was probably the most useful sign of moose at any altitude up to 1300 ft.

2. Color contrast. The brown pelage of the moose was fully visible against the darker color of the water and even the light green vegetation at the edges of water areas.

3. Circular ripples on water. Frequently this was the only indication of an animal otherwise shielded from view by stumps or shadows.

4. Shadow. This sign was most valuable when the animal was standing on sphagnum covered edges of lakes and streams especially when observing in the direction of the sun.

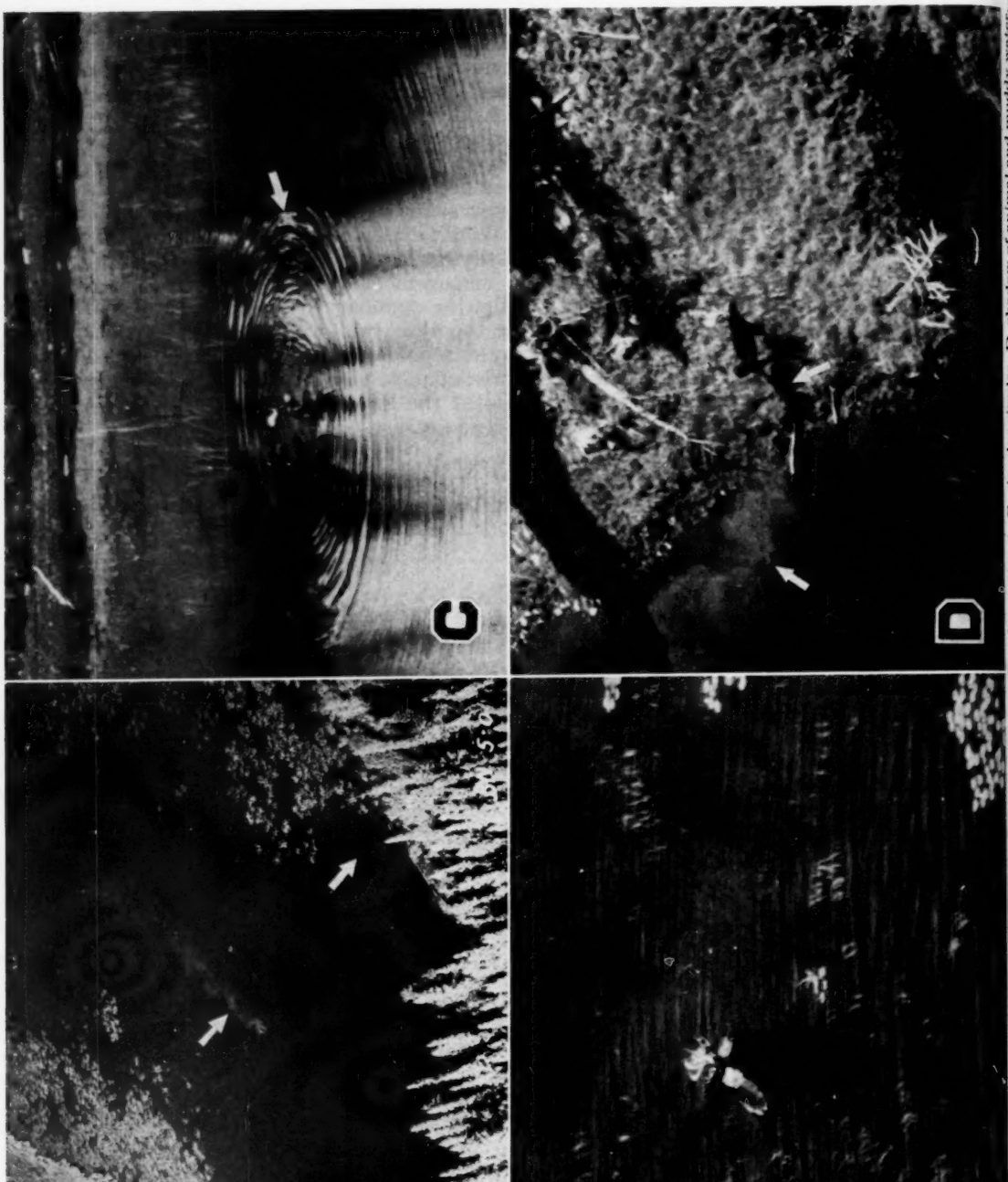
5. Trails on bottom of lake. These were conspicuous at the edges of shallow lakes where the water was generally quiet. The presence of water lilies often alerted the observer for signs of footprints.

Wildlife administrators are obliged to justify the cost of an aerial survey in terms of management information obtained. The following summary of operational expenses for the three-and-one-half-week aerial survey of moose shows that such costs are not unreasonably high especially if balanced against the importance of the species as a revenue earner.

Salary and field expenses for photographer and recorder	$1,300.00
Airplane charter (including pilot)	1,500.00
Photographic materials	100.00
Total	$2,900.00

SUMMARY AND CONCLUSIONS

In view of the isolation and great expanse of the moose habitat in the Province of Ontario, it would appear that an aerial reconnaissance of moose in summer, with its speed and facility and also its temporal proximity to the hunting season, provides a practical means for obtaining a useful index to the population size of moose. The results of the present experimental survey suggest that the "water-course" census method as employed in the Chapleau area was somewhat more accurate then the "strip" census method. Because moose could not be detected in the forested areas the "strip" census method would seem to be wasteful of flight time. The optimum flying altitude on clear days was found to be about 400 feet. At this altitude sex identification, in so far as this is possible, was found to be very reliable. Temperature and correlated factors such as relative humidity, time of day and season, seemed to be important in determining the number of moose present in water areas. More moose were observed in shallow lakes than in streams. There is little reason to suggest that the sight or sound of the airplane frightened many moose. Indicators for the easy detection of moose in water areas are described and illustrated with photographs. The total cost of the three-and-one-


C
D
A
B

half-week moose census, including salaries, field expenses, photographic materials, and airplane charter, was slightly less than $3000. The value of knowing the population trends of moose as a basis for the proper regulation of hunting would seem to justify the relatively small expense involved in obtaining the management information by means of an aerial reconnaissance.

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THE WILDLIFE SOCIETY

REPORT OF THE EXECUTIVE SECRETARY FOR THE YEAR 1954-55

General Activities

Early in the Society's fiscal year special committees recommended procedures for stream-lining the annual business meeting and studied means of reducing costs per printed page of the Journal and Wildlife Society News. Another Committee studied the problem of Regions and Sections within the Society to determine adequacy of membership representation. The newly organized California and Northwest Sections carried on active programs and held successful annual meetings, as did the older established Southeast Section. The Minnesota Section prepared and submitted for consideration of Minnesota's new governor a policy for game and fish management within the State. The Northeast Section took an active part in preparing for the joint Northeast Wildlife and Fisheries Meeting.

Routine duties of the Office of Executive Secretary consisted primarily of processing new memberships, membership renewals, and subscriptions; sending invoices to subscribers; placing orders for current and back issues of the Journal and for copies of the 10-year Index and symposia on farm ponds and cycles in animal populations; making changes of addresses for members and subscribers; distributing membership blanks; working with the various Society committees; answering requests for information on professional opportunities and training; and handling the fiscal business of the Society.

Membership

The Wildlife Society is growing at a good pace, as indicated below:

Class of Membership	Number of paid-up Members at the close of December		
	1952	1953	1954
Honorary	11	13	15
Life	10	10	17
Regular	1919	2140	2346
Subscriber	388	377	406
Total	2328	2540	2784

As of the end of February 1955, we had 15 Honorary, 20 Life, and 2203 paid-up regular Members, and 408 Subscribers for 1955. Also, many of the last year's 343 Members and 53 Subscribers who had not paid their 1955 dues at the close of the fiscal year will probably do so. These, together with additional new Members and Subscribers may well swell our ranks to 3000 by the end of 1955. Thus, 374 new

Members were taken into the Society during 1953, 424 during 1954, and to date, for 1955, 183. Detracting from this gain in new Members is the considerable number of members (about 9%) who drop out from one year to the next. Of 210 1953 Members who did not renew for 1954, approximately 41% had been Members for only one year, 18% for two years, 9% for three years, 24% for from four to ten years and 8% for more than 10 years.

The deaths of the following Members are regretfully reported: E. F. Chatelain, F. D. Haller, F. S. Parker, R. F. Shuman, and D. W. Shutt. Unreported last year was the death of John W. Freese. The attention of the Memorials Committee was directed to these deaths.

Nominations and Election Results

Mail balloting for Regional Representatives resulted in nominations as follows: Region I—Roger Latham and William Sheldon; Region II—Leonard Foote and C. E. Carlson; Region III—D. W. Douglass and S. C. Whitlock; Region IV—Lee Yeager and Ralph Hill; Region V—Wendell Swank and F. M. Baumgartner; Region VI—A. S. Leopold and J. B. Lauckhart; and Region VII—Ian McT. Cowan and C. D. Fowle.

The Nominating Committee, under the Chairmanship of Charles A. Dambach, nominated Justin W. Leonard and John S. Gottschalk for President, and E. L. Cheatum and H. W. Olds for Vice-President. Tabulation and audit of the election ballots showed the winning candidates for Regional Representatives, President and Vice-President to be those named first in each of the offices listed above. One Member, in commending the Nominating Committee for the selection of fisheries and wildlife biologists respectively for President and Vice-President, recommended that succeeding Committees alternate this arrangement from year to year to insure adequate representation of wildlife and fisheries interests in Society affairs.

Affiliations

The Society maintained its affiliations with the International Union for the Protection of Nature, President Swanson representing the Society at the Congress in Copenhagen, Denmark; the Natural Resources Council of America, the Society being represented at various meetings by Clarence Cottam and your Secretary; and the National Research Council. Arrangements were consummated for the Society to become, without dues payments, a participating member of the International Science Foundation. Starker Leopold is serving as a liaison with a Committee of the International Science Center at San Francisco which is working on a handbook of the scientific resources of that area. Contact is being maintained, also, with the A.A.A.S.; A. E. Borell has been designated to represent our Society at the Arid Lands Conference which is being sponsored by the A.A.A.S. in April. John M. Anderson represented the Society at the Waterfowl Advisory Committee Meeting in August and your Secretary was delegate to the first National Watershed Congress as reported in Wildlife Society News.

FINANCIAL REPORT

Following is the audited financial report of the Wildlife Society Inc. for the fiscal year March 1, 1954 to February 28, 1955.

ASSETS

Cash			
Checking Account (Bank of Silver Spring, Md.)		$9,779.94	
Savings Account (Bank of Silver Spring, Md.)		4,138.39	
Permanent Fund (Emigrant Ind. Savings Bank, N. Y.)		9,574.50	$23,492.83
Securities — Market Values			
22 shares State Street Investment Corp.		1,592.00	
30 shares Loomis-Sayles Mutual Fund, Inc.		1,290.60	
U. S. Government Bonds Series G — 12 yr. bonds			
Serial No.	*Cost*	*Date of Purchase*	
D2576621G	500.00	April, 1947	482.00	
D2576622G	500.00	April, 1947	482.00	
D2943626G	500.00	Sept., 1948	477.50	
D2943627G	500.00	Sept., 1948	477.50	4,801.60
Total Assets				$28,294.43

STATEMENTS OF RECEIPTS AND DISBURSEMENTS

Bank Balance March 1, 1954			$17,314.95
Receipts (deposited to checking account):			
Dues	$16,006.85		
Subscriptions	2,380.94		
Sales:			
Back Issues, Journal	762.30		
Animal Cycle Symposium	177.33		
Farm Pond Symposium	24.00		
10-Year Index	33.00		
Membership List	7.50		
Chatelain Obituary Photos	7.00	$19,398.92	
Receipts (deposited to savings account):			
Dividends and Interest	$ 580.51		
Life Membership Dues	450.00		
Gifts and/or Refunds	12.15	1,042.66	20,441.58
			$37,756.53
Disbursements:			
Journal, Printing and Mailing		$10,520.72	
Mailing Back Issues of Journal, Reprints		162.52	
News, Printing, Folding and Mailing		616.33	
Editor's Expense		131.40	
General Supplies, Printing and Communications (including postage, mailing ballots, dues, notices, etc.)		946.85	
Executive Secretary:			
Clerical Assistance	700.00		
Honorarium	700.00		
Travel and Meeting Expense	26.40	1,426.40	
Refunds, Bank Charges, Bad Checks		94.90	
Affiliation Dues (I.U.P.N. Nat. Res. Council)		100.00	
Meeting Expense (Employment Desk, Awards, etc.)		86.96	
Audit 1953–1954		20.00	
Reprints (By-Laws, etc.)		26.50	
Miscellaneous Expenses		131.12	14,263.70
Bank Balance February 28, 1955			$23,492.83

The Executive Secretary is bonded in the amount of $20,000. The stock of JOURNALS held at Cayuga Press, Ithaca, New York, is insured in the amount of $6,000 for fire and $6,000 for sprinkler leakage with the Continental Insurance Company. The respective expiration dates for the bond and insurance policies are August 24 and May 5, 1956.

Respectfully submitted,
S/Daniel L. Leedy
DANIEL L. LEEDY, *Executive Secretary*

REPORT OF THE WILDLIFE SOCIETY COUNCIL MEETING, MARCH 13, 1955

The Council assembled at 7:30 P.M., March 13, in the Sheraton-Mt. Royal Hotel, Montreal, Canada. Members present were Gustav A. Swanson, President; Thomas R. Evans, Vice-President; C. H. D. Clarke, Past President; and Roger M. Latham, Leonard E. Foote, D. W. Douglass, Lee E. Yeager, J. B. Lauckhart, and Ian McT. Cowan, Representatives of Regions 1, 2, 3, 4, 6 and 7, respectively. Region 5 was not represented officially. Non-voting members of the Council who attended the Meeting were Daniel L. Leedy, Executive Secretary, and O. H. Hewitt, Editor.

The Council appointed Edward H. Graham to succeed Charles B. Belt as Trustee. Daniel L. Leedy and O. H. Hewitt were retained as Executive Secretary and Editor respectively. Thomas R. Evans was appointed Editor of The Wildlife Society news subject to the latter's approval on mature consideration. Evans would thus succeed Henry S. Mosby who, after serving efficiently for several years, asked to be relieved of this position. Louis Krumholz was retained as Associate Editor of the Journal and E. L. Kozicky also was named as Associate Editor to assist with statistical manuscripts.

Arthur A. Allen and Paul L. Errington received unanimous approval of the Council for Honorary Membership.

Editor Hewitt reported that he had over a year's backlog of manuscripts and that with Council approval he had arranged for alteration in the form of printing which had been recommended by the Publications Cost Committee—said change to be effective with the July, 1955, issue of the Journal. The change, by placing more type on each page, will save approximately $500 in paper during the year and thus permit the publication of more papers.

To allow for further expansion of the Journal and to promote other Society activities, the Council recommended that annual dues be increased from $5.00 to $6.00, and that the question of dues increase be brought before the Members at the Annual Business Meeting.

The Council approved publishing of the Membership List by off-set print if it were determined that such a method would save at least $200. The Membership List is to be bound in with the October, 1955, issue of the Journal and 50 reprints made available for Society use.

The Council urges that Society Members submit for consideration any manuscripts they may have which might possibly be published by the Society as Special Monographs, Bulletins or Books. It was suggested that upon receipt of such special manuscripts the problem of financing them would be referred to the Trustees for possible solution. Members were also urged to suggest additional subjects for symposia inasmuch as the first two have brought considerable recognition to the Society.

Other Journal matters considered included out-of-print issues and obituary reprints. Editor Hewitt reported that 13 issues were out-of-print and that 15 additional issues were available in numbers of 50 or less. It was not considered feasible to reprint these issues until more demand for them was evident. Twelve to 25 extra copies of page proofs were considered ample to meet obituary needs.

The Council voted to retain a Committee on Resolutions and approved seven resolutions presented by the current Committee.

Continued affiliation with the I.U.P.N., the Natural Resources Council of America, the National Research Council, and the International Science Foundation was recommended.

The report of the Committee on Regions and Sections was accepted with thanks and it was agreed that it should be published in full in The Wildlife Society News to obtain reaction of the membership to the Committee's recommendations. The Council ruled that voting Members of Society Sections must be Members of the parent Society.

Since a change in order of business at the Annual Meeting and other amendments to the By-Laws are indicated, it was recommended that the incoming President appoint a By-Laws Revision Committee. It was also recommended that a committee consisting in part, at least, of previous Chairmen of Awards Committees, be appointed to draw up guide-lines or standing orders of procedure for making the various awards.

The Council recognized the difficulty of comparing the conservation education values

of publications, audio-visual productions, and general conservation education programs, and approved the recommendations of this year's Committee to make two awards in this field. It was agreed that Committees on Conservation Education Awards should normally bring in only one nomination for an award; however, if said committees have truly outstanding works or projects in two or more areas of conservation education, they were instructed to contact the Council for authority to make more than one award.

The Council approved a budget of $15,500 for the period March 1, 1955 to February 28, 1956, with items as follows:

Journal of Wildlife Management	$10,600
Membership list and reprints	700
Wildlife Society News	700
Mailing back issues, reprints, etc	200
Editor's expenses	150
Miscellaneous supplies, printing, postage and express, including mailing of ballots, dues notices, etc	1,100
Affiliations: I.U.P.N., Natural Resources Council	100
Meeting expenses: Employment Desk, delegates, awards	100
Executive Secretary:	
Honorarium	700
Clerical Assistance	700
Travel and meeting expenses	200
Contingency fund	250
	$15,500

A proposal for the Society to issue Membership cards to members upon payment of dues was voted down as was a suggestion that the Society have lapel buttons and/or pins.

A discussion of the feasibility of having a Society library and exchanging the Journal for other publications resulted in a recommendation that the incoming President appoint a committee to consider the question in detail.

The meeting adjourned at 11:30 P.M.

Respectfully submitted,

DANIEL L. LEEDY,
Executive Secretary

MINUTES OF THE ANNUAL MEETING, MARCH 14, 1955

The nineteenth annual business meeting of The Wildlife Society was called to order by President Gustav A. Swanson at 8:00 P.M. March 14, 1955, at the Sheraton-Mt. Royal Hotel, Montreal, Canada.

A motion to change the order of business in keeping with the recommendations of the *ad hoc* Stream-lining Committee was carried and minutes of the previous meeting were approved as published in the Journal of Wildlife Management, **18**(3): 375–377.

In a brief report the President mentioned his trip abroad, acknowledged with thanks the yeoman service of Vice-President Evans during that absence from the country, and pointed out the increasing interest of Europeans in The Wildlife Society. The Executive Secretary then gave his report. He stated that there had been a net increase of more than 450 members and subscribers during the past two years and referred the members to the multilithed copies of his report (available in the meeting room) for details on income and disbursement during the year.

The report of the Council Meeting held March 13 was accepted as read by the Executive Secretary. Drs. Arthur A. Allen and Paul L. Errington were elected to Honorary Membership in the Society, bringing the total of such Members to 17.

Reports of the Committees on Awards were then given and signed certificates were presented to Durward L. Allen and Allen W. Stokes, the only award winners present to receive their awards. (Presentation of the Leopold Medal, according to custom, was made at the annual banquet of the North American Wildlife Conference on March 15. Clarence Cottam was the recipient).

In presenting the Employment Committee's report, Victor Solman indicated that more available jobs were posted at the Society's Employment Desk than there were applications submitted by members in attendance at the Conference.

After the reading of the report of the Job Standards Committee by President-Elect Justin W. Leonard, Norman Wilder suggested that the findings of this and previous committees on standards be summarized and made available to the membership by

publication in the News. This was approved as was also the publication of reports of the Society's Regions and Sections.

Recommendations of the *ad hoc* Committee on Publication Costs were reviewed by the President. He pointed out that by increasing the type bed, some $500 in printing costs could be saved yearly.

Resolutions were passed as follows:

1. WHEREAS, the National Forests have annually provided recreational public use facilities for approximately thirty million people during recent years, and adequate funds have not been available to properly maintain and develop recreational facilities and wildlife habitat, now therefore,

   BE IT RESOLVED, That The Wildlife Society does hereby go on record as endorsing the principles of the Metcalf Bill H.R. 1823, as introduced in the 84th Congress, and

   BE IT FURTHER RESOLVED, That the Wildlife Society urges the enactment of legislation that will earmark 10 per cent of the annual receipts from the national forests, but not to exceed $5,500,000 in any year, and make it available to the Secretary of Agriculture, for the above described purposes.

2. WHEREAS, it is generally recognized that present mining laws are antiquated and that there is a need to separate surface rights from mineral rights in the public lands administered by the U.S. Forest Service to prevent exploitation of our natural resources, and

   WHEREAS, values, other than mineral, such as grassland, timber, wildlife habitat, watershed protection, and recreational use on such public lands have now become of greater importance than mineral rights, now therefore,

   BE IT RESOLVED, That The Wildlife Society urges the passage of legislation calling for the separation of surface from mineral rights and that which gives proper consideration to the broad public interest in all natural values.

3. WHEREAS, the Great Lakes Fisheries Convention has been signed by the United States and Canada for purposes of sea lamprey control and encouragement of research in the Great Lakes, and as such joint research in the case of other fishery conventions has led to worthwhile benefits, now therefore,

   BE IT RESOLVED, That The Wildlife Society requests the respective governments of the United States and Canada to initiate early legislative ratification of the convention.

4. WHEREAS, an accumulated surplus of approximately $13,500,000 of Federal Aid to Wildlife Restoration funds exists, and these unappropriated funds were collected from sportsmen for the specific purpose of restoring our wildlife resources, now therefore,

   BE IT RESOLVED, That The Wildlife Society urges the Congress of the United States to make these reserve funds available to the states for wildlife restoration purposes.

5. WHEREAS, the wild European rabbit (*Oryctolagus c. cuniculatus L.*) is a pest within its native and introduced range, and annually causes the loss of millions of dollars to agriculture and entails great expenditures for control, and

   WHEREAS, a domesticated form of this animal has flourished on the San Juan Islands, off the coast of the State of Washington, and sportsmen's organizations have obtained and released these animals in some states, now therefore,

   BE IT RESOLVED, That The Wildlife Society urges that the practice of releasing this species be discouraged and urges legislation to prohibit intrastate and interstate shipments.

6. WHEREAS, The Wildlife Review and the newly issued summary volume of Wildlife Abstracts are research tools of very great value to wildlife investigators throughout the world, now therefore,

   BE IT RESOLVED, That The Wildlife Society commends the U.S. Fish and Wildlife Service and its staff members for issuing these publications.

7. RESOLVED, That the Wildlife Society extend to the Wildlife Management Institute, to members of the Program Committee of the 20th North American Wildlife Conference, and to the Shera-

ton-Mount Royal Hotel of Montreal, Quebec, Canada, grateful appreciation for cooperation, facilities, and courtesies that contributed to the success of the Society's annual meeting.

John M. Anderson reported on his attendance as The Wildlife Society representative at the meeting of the Waterfowl Advisory Committee in Washington, D. C., August 4 and 5, 1954. He considered it an important function of the Society to have as a representative on this Advisory Committee, a waterfowl biologist, free to base his recommendations upon facts of waterfowl biology without regard to any state or federal government affiliation. He indicated that the effectiveness of the Advisory Committee could be increased if the Flyway Councils had sufficient faith in their respective representatives that the latter could vote on unexpected problems.

Durward L. Allen reported progress during the period in which he has represented the Society on the National Research Council. Recently a Conservation Board has been established within the Division of Biology and Agriculture and Allen believes that more attention will be placed on the broad ecological phases of resource management.

Brief reports were made by the President and Executive Secretary respectively on the Society's affiliation with the International Union for the Protection of Nature, and the Natural Resources Council of America. Continued affiliation with these organizations was deemed advisable.

A discussion of special publications was the only item of unfinished business considered. Members were urged to submit papers for consideration of the Editor with the assurance that an effort would be made by the Society to find means of publishing those deemed suitable.

To permit enlargement of the Journal and promote other Society activities a motion was made to increase annual membership dues from $5.00 to $6.00. After a brief discussion, the question was put to the members in attendance at the meeting (approximately 175) and the motion was unanimously passed. A proposed amendment to the By-Laws to increase the dues will be referred to the Society for action by mail ballot during the year.

As no additional business was brought up, the meeting adjourned at 9:40 P.M.

Respectfully submitted,

DANIEL L. LEEDY,
Executive Secretary

REPORT OF THE AWARDS COMMITTEE ON CONSERVATION EDUCATION, MARCH 1955

The Committee this year experienced the impossible task of selecting from the nominations, a single conservation education project as the best accomplishment of the year. The reason for this dilemma is that no equitable base for comparing the values of written works, audio-visual productions, and program projects exists.

Key people in each Province and State were contacted for the year's nominations by direct mailings from the Committee. A total of 54 nominations were received from both countries. Eleven were for written works, eight for programmed projects, and seven in audio visual productions. Three projects received duplicate nominations. From these nominations the Committee recommends two for this year's Conservation Education Award.

Ted S. Pettit is recommended to the Society for his outstanding work in organizing, promoting, and writing, that insured the success of the "Conservation Good Turn" program of the Boy Scouts of America. The objective of the program was to have 3½ million boy scouts arouse public interest in conservation of our natural resources. The success of the program can best be measured by evaluation made by natural resource technicians and administrators' interest displayed by the general public; by the large number of articles in the press; stories on the radio; and treatment by television; and the many magazines. Most important of all the largest national youth organizations, The Boy Scouts of America though principally located in our urban areas has now established a permanent conservation pro-

gram for the training of our future citizens.

Dr. Durward L. Allen is also recommended to the Society for his monumental book "Our Wildlife Legacy," (Funk and Wagnalls Company, 1954). The wide scope of the subject matter in his book is covered with a remarkably high degree of factual accuracy. The most important contribution is the manner in which the accounts have been developed in an interesting and extremely readable manner. The author's style results in a reference book of equal value to technicians, teachers, students, sportsmens groups, administrators, and key conservation people throughout the country.

Honorable mention includes the nominations of: Handbook for Idaho Teachers; a group of publications issued by the Oregon Game Commission that were published or revised during 1953 and 1954; Oregon's Conservation Education Program in summer camps; Florida's Junior Conservation Club League; Tennessee's Camp Counseling Program; Iowa's Outdoor shop Talk, a series of 23, 16 mm. films, 13½-minutes long and shown on 13 stations throughout the State; North Carolina's Better Fishing, a 29-minute sound color film; Outdoors in Illinois, a 15-minute weekly radio program on 44 Illinois and 2 Iowa stations.

Respectfully submitted,

MALCOLM M. HARGRAVES
JOSEPH J. SHOMON
W. KENNETH THOMPSON
CLARK B. WALSH
JACK CULBREATH,
Chairman

REPORT OF THE AWARDS COMMITTEE, FISHERIES PUBLICATIONS, MARCH 1954

The Committee was unanimous in the decision that the award for the outstanding fisheries publication for 1953–54 should go to Dr. William E. Ricker for his "Stock and recruitment" (Jour. Fish. Res. Bd. Canada **11**(5): 559–623). At the same time we wish to acknowledge the debt which fisheries biologists owe Dr. Ricker for his previous contributions in statistical treatment of fish populations and their dynamics.

From a long list of significant papers and books, the Committee selected the following for special honorable mention: Dr. Shelby Gerking, "The food turnover of a bluegill population" (Ecology **35**(4): 490–498); Dr. D. A. Webster, "Smallmouth bass in Cayuga Lake" (Cornell Univ. Expt. Sta. Mem. 327. 39 pp.); Dr. W. A. Kennedy, "Tagging returns, age studies and fluctuations in abundance of Lake Winnipeg whitefish" (Jour. Fish. Res. Bd. Canada, **11**(3): 284–309); Dr. Eric Fabricius, "Aquarium observations on the spawning behavior of the char, *Salmo alpinus*" (Inst. Freshwater Res., Drottningholm, Rept. **34**: 14–48); and Dr. George W. Bennett, "Largemouth bass in Ridge Lake, Coles County, Illinois (Bull. Ill. Nat. Hist. Survey Vol. 26, Art. 2).

The Committee wishes to acknowledge the service which Dr. R. W. Eschmeyer is providing fisheries biologists in his regular reviews and comments in the "Sport Fishing Bulletin," and in particular "Highlights of 1953" and "Fish Conservation Fundamentals."

ROBERT C. BALL
JOHN GOTTSCHALK
PAUL R. NEEDHAM
WILLIAM F. SIGLER
KENNETH D. CARLANDER,
Chairman

REPORT OF AWARDS COMMITTEE, TERRESTRIAL PUBLICATIONS, MARCH, 1955

The Committee, having reviewed much of the wildlife literature published in 1953 and 1954 and solicited recommendations in various ways from members of the Society and others, nominates "Population Studies of the Ring-necked Pheasants on Pelee Island, Ontario" by Allen W. Stokes for The Wildlife Society's Terrestrial Publications Award. This was published as Technical Bulletin (Wildlife Series No. 4), Ontario Dept. of Lands and Forests, Toronto, Canada; 154 pp., 44 figures, 70 tables. Candidate publications were appraised on thoroughness of planning, adequacy of data, clarity of analyses, manner of presentation, originality of research, and essentiality as a contribution to the literature of wildlife ecology and management. In the opinion of the Committee, the selected publication meets these standards admirably.

Recommended for Honorable Mention are the following:

Dwight R. Smith, 1954—"The Bighorn Sheep in Idaho"; Wildlife Bulletin No. 1, pp. 154, ill., Dept. of Fish and Game, Boise, Idaho.

V. W. Lehmann, 1953—"Bobwhite Quail Populations and Vitamin A"; Trans. 18th North American Wildlife Conf., 199–246.

G. W. Gullion, 1954—"The Reproductive Cycle of American Coots in California"; Auk **71**:366–412.

At the same time, the Committee recognizes the many publications of obvious merit that deserve the encouragement of formal Society recognition. Outstanding are two—Durward L. Allen's "Our Wildlife Legacy" and A. C. Bent's "Life Histories of North American Wood Warblers"—which as compilations and not "original" research seem to be excluded by traditional guidelines. In addition, the consideration of the Society is invited to the extreme difficulties of finding a fair and satisfactory basis on which to compare short journal papers with books or bulletins.

Respectfully submitted,

DAVID A. MUNRO
DON C. QUIMBY
WILLIAM G. SHELDON
LYLE K. SOWLS
PAUL HICKIE, *Chairman*

REPORT OF THE EMPLOYMENT COMMITTEE, MARCH 1955

The Employment Committee has now completed its sixth consecutive year of obtaining information on students majoring in fish and wildlife work in colleges and universities in the United States, Alaska, and Canada. This is the fourth year information has been solicited regarding employment of fish and game technicians by State, Provincial and Federal agencies. Previous reports have been published in the July issues of Volumes 14, 15, 16, 17, and 18 of the Journal of Wildlife Management.

The same group of schools was sent questionnaires this year as last and all State and Provincial game and fish departments and Federal agencies with wildlife responsibilities were also circularized as in the past.

STUDENTS

Forty-five schools responded to the questionnaire. Eight of the institutions did not offer undergraduate training in wildlife work and five did not classify wildlife students until the junior year. However, these institutions provide the undergraduate with basic biological training suitable for majoring in wildlife management or pursuing graduate studies in that field. As a result of the above differences in classification, there will appear to be a shortage in the number of first and second year students in relation to juniors and seniors. There were 1,211 undergraduates registered in the 45 schools, distributed as follows: 387 freshmen, 290 sophomores, 264 juniors, and 270 seniors. The graduate enrollment was 406, with 260 pursuing Master and 148 Doctor's degrees. The 1954 graduating classes included 236 Bachelors, 110 Masters, and 26 Doctorates.

The current status of the 1954 graduates from the 45 schools returning questionnaires is shown in the following table.

	Bachelors	*Masters*	*Doctorates*	*Totals*
Game Research	4	13	5	22
Game Management	21	19	0	40
Fish Research	17	11	4	32
Fish Management	9	9	0	18
Fish and Game Research or Mgt.	3	0	1	4
Law Enforcement	4	1	0	5
Public Relations	3	4	1	8
Wildlife Teaching	2	2	8	12
Back to School	54	22	2	78
Teaching Non-Wildlife Work	1	4	1	6
In Military Service	84	16	3	103
Other Employment	18	10	1	28
Unknown	16	2	0	18
	236	110	26	374

This committee now has a six-year record of undergraduates and graduate students from 27 colleges and universities that should be representative of the trend in fish and wildlife training in this country. The number of undergraduates starting in 1949–50 and continuing through 1954–55 were: 1,222, 1,063, 996, 1,021, 893, and 844, respectively. For graduate students during the same period, the figures were: 281, 363, 352, 304, 320, and 264. In general, the trend has been downward which would indicate that the profession is about at saturation point. This is particularly true in the wildlife field, but less so for fishery employment.

Out of the 374 graduating, 21 percent went back to school and 28 percent went into military service. Further analysis shows that only 141, or 38 percent, of the 1954 graduates were employed in the game and fish field. From the 1952–53 graduates, 52 percent were employed in the field of their training.

EMPLOYMENT NEEDS OF CONSERVATION AGENCIES

All State and Provincial game and fish departments and Federal agencies employing fish and wildlife technicians were sent questionnaires. Replies were received from 41 States, 3 Provinces, Alaska, the Soil Conservation Service, the Fish and Wildlife Service, the Forest Service, and the Canadian Wildlife Service. Only the 41 States, Alaska, 3 Provinces, and the Fish and Wildlife Service supplied information that could be used in this tabulation. The Forest Service employs only trained foresters, the Soil Conservation Service is not presently employing trained biologists and the Canadian Wildlife Service recruits only from their Civil Service lists and such individuals must be Canadian citizens and have lived in Canada for at least five years.

In last year's questionnaire, the game and fish administrators reported that they had already hired or expected to hire a total of 1,599 employees consisting of 638 permanent and 961 seasonal or temporary appointments. From the 1955 questionnaire, it was learned that they actually hired 546 permanent employees and 725 seasonal or temporary employees, or a total of 1,271. This was approximately 20 percent less than was predicted.

This year these same administrators have already hired 766 employees and expect to hire 850 more, making a total of 1,619 of which 789 will be full time and 830 temporary positions. It was indicated that 384 of these positions would be replacements. Sixty percent of the replacements would be in the warden staffs. Last year 51 percent of the replacements was in the warden category.

Looking into the future needs for fish and wildlife personnel, the trend seems to be divided. About half indicated the employment situation would remain the same and the other half thought there would be a need for more trained personnel. The following table shows the response of administrators to future needs.

(Future needs in personnel expressed in percentage of those replying to questionnaire.)

	To increase:	*To decrease:*	*Remain the same:*
Fish Technicians	53	2	45
Game Technicians	20	2	77
Wardens	34	2	64
Information and Education	49	0	51

EMPLOYMENT SERVICE

At the 19th North American Wildlife Conference, 66 individuals filed applications at the job referral desk. Since that time and up until the opening of the 20th North American Wildlife Conference, the list of

applicants has grown to 144. During the conference an additional 38 applications for employment were filed.

Requests for assistance in filling positions were received from 10 administrators during the year. Suggested personnel and their qualifications as listed on the employment applications were supplied to these men. The employment desk at the 20th North American Conference was operated from noon, March 13, until the close of the conference. During this period, 64 job openings were listed with the Committee. This included a need for 33 fishery biologists, 1 fishery pathologist, 12 research biologists, 7 big game biologists, 8 information and education men, 2 graduate assistantships at 2 universities, and 1 teaching job at a university. These job openings were in 9 states, 1 province, Alaska, 3 universities, the Soil Conservation Service, the Fish and Wildlife Service, and the Texas Wildlife Federation.

The interest shown at the employment desk this year indicates that this service can and is performing a valuable function in the wildlife field and we recommend that it be continued throughout the year and at succeeding wildlife conferences. Similar employment desks have been in operation at some of the sectional wildlife meetings and each has reported favorable reaction to this service.

Whether or not our services have been of value is not known as neither employer nor employee has informed the Committee of decisions made. This is a serious weakness in our system. There should be some way of knowing when prospective employees have received jobs so their names can be removed from our files. When jobs are filled, we would also like to know whether our services were helpful in locating suitable personnel. To remedy this situation the Committee suggests that agencies hiring men from this listing inform the Office of the Executive Secretary. The problem of maintenance of the list is also of importance. The Committee proposes to remove application forms following the second conference after they have been filed.

Council action on these two points is requested.

Respectfully submitted,

WILLIAM H. MARSHALL
VICTOR E. F. SOLMAN
SHALER E. ALDOUS,
Chairman

OBITUARY

DAVE HARRIS

Dave Harris, Active Member of the Wildlife Society, and for 20 years a State Game Warden with the State of South Dakota, died February 27, 1955. Probably no other game warden had such a wide friendship with recognized wildlife authorities throughout the United States. Certainly, few self-educated members of the Society have earned equal esteem of the profession.

His many friends appreciated Dave's practical application of the fundamental principles of wildlife management. The northern Black Hills was his testing ground; there, theories met the critical test of practicality—or went to discard. It was there in 1940, through his recognition of the need for sound biological facts, and through his efforts, that South Dakota's first Federal-Aid program was organized. Although he published several articles in the Journal of Wildlife Management, his real interest lay in lasting developments on the ground. Honorary recognition, through a Certificate of Merit in the Nash Conservation Award program, and the Conservation Award of the Woodmen of the World was truly earned.

Locally, Dave was better known for his tireless, efficient law enforcement; his active work in fire control; and his constant effort in promoting the welfare of wildlife toward its rightful place in this highly developed forest community. He never gave up in a fight for the things he knew were right. He gave his time constantly toward the wise use of soils and waters, forest and range, game and fish. He studied, taught, and practiced conservation. Each year thousands of boys and girls—Scouts, 4-H Club members, Future Farmers—learned from him the real meaning of conservation out on the ground. That was his life.

And so it is fitting that he be remembered by the Dave Harris Junior Conservation Memorial—a student conservation award—made possible by contributions from his many friends throughout the country.—RALPH R. HILL

REVIEWS

High Tide and An East Wind. By Bruce S. Wright. The Story of the Black Duck. The Stackpole Company, Harrisburg, Pennsylvania. 162 pages. 1954. $4.50.

This book, a life history and ecological study of the Black Duck, is a welcome addition to the bookshelves of both the Northeastern waterfowler and the game manager. That this number one duck of the Northeast has not previously been written up in such detail is rather amazing, but perhaps the independence, individualism and wariness of this creature has prevented all but the most persistent researchers from knowing the "blackie" personally.

The author makes it clear in the preface that two fairly distinct populations of Black Duck exist—one maritime and the other interior—and that this study was based primarily on the maritime group. The reader should keep this in mind. Those of us who have had the good fortune to observe the Black Duck in both environments find that in the New York coastal marshes this species is rather conservative, choosing fairly definite ecological niches for nesting while the interior black is basically a pioneer making the best of the habitat available. Contrastingly Wright found a high degree of adaptability in the maritime population nesting in the St. John River lowlands.

Several observations are presented by the author demonstrating sexual interest both on the part of young of the year and adults in the fall but the author further suggests that this may be only temporary pairing or only indulged in by a portion of the population since many return unpaired in the spring. Fall banding experiences by other workers strongly indicate this is true since both with Black Ducks and other species a degree of sexual segregation has been observed with traps on one part of a marsh taking more males than females and another the reverse. Considerable admiration must be felt for the author who has made many observations which required separating the sexes both on the water and in the air. Differentiating between the sexes is perfectly feasible but requires close observation and long familiarity with the species.

Data presented indicative of the feeding habits of the Black Duck are not extensive but clearly indicate the versatility of this species in making the best of what is available whether in the water or on the land. The bits of mortality data tucked away here and there through the book make interesting reading and suggest that man in the maritimes as a fur trapper and north of the St. Lawrence for survival may be as limiting a factor in duck abundance as predator species. The author implies that the Great Horned Owl may be an important predator but his list of "kills" in the appendix shows no known cases of owl predation on the New Brunswick study area.

"The drake is led by his hen back to her traditional breeding area, where she begins hunting for a nest site." To a degree this behavior, which has been implied by many writers, probably is true but accumulating band returns suggest about as high a rate of homing among the males as the females.

In the section on nesting the author indicates the average first brood as hatching May 16 but gives no period for the peak of the first hatch. Such data would be good for comparison with other regions since few workers are out enough to determine accurately the average first brood.

The sections on the summer life of the black ducks make very interesting reading but may leave the reader a trifle confused. The author indicates an average brood survival of 5.7 young in Class II but 6.3 in Class III. The difference is credited to the fusion of broods when the female leaves to moult yet he ends the chapter with the statement "Thus 6.3 ducklings reach the flying stage. . . ."

The author mentions and accepts the currently held opinion that the "Northern Red-Legs" are merely adult birds which have come south late. It is to be hoped that current banding activities in the northern range of the black will settle this controversy for once and for all. In the same paragraph he states ". . . but they are more likely old birds that will not enter a trap." It doesn't seem as if adequate data are available to indicate that adults are either more or less susceptible to trapping.

Table V presents the sex and age ratios of all species lumped together for the season on St. John River. Without separating the species these data seem to have little value.

In the section on management the author introduces a germ of thought that waterfowl may be cyclic though he makes no implication that his own data are indicative of cyclic behavior. Life equation tables are presented for a stable population indicating that man is probably the most important limiting factor of the species and that control of legal hunting is probably the most important management tool.

To the reader I recommend this book not for the new scientific data which it presents but for the excellent resume which it gives of waterfowl problems in general and the black duck in particular in Eastern Canada and the Maritimes. Probably several states have as much nesting and brood data tucked away in their files as the author but Bruce Wright has presented a broad picture which many of us fail to see.—Dirck Benson.

Culture and Diseases of Game Fishes. By H. S. Davis. University of California Press, Berkeley and Los Angeles. x+325 pp. +55 figures, 7 appendices. 1953. $5.00.

In reviewing this book, such time-worn expressions as "the author has filled a long-felt need" and

"here is a worthwhile contribution to the field" repeatedly come to mind. Indeed, both ideas are applicable here. There was a time in the not-too-distant past when workers could keep abreast of the developments in even a fairly broad field. But rapid advances in scientific endeavour have resulted in many chasms which more or less isolate specialists and fields. The time is appropriate for bringing together techniques, ideas, and principles in various phases of fisheries biology. Dr. Davis has accomplished, to a worthwhile degree, such a synthesis in the fields of fish culture and fish parasitology and pathology.

The dust cover of the book tells us that the account is written for those interested in the conservation, management, and culture of freshwater game fishes. There would appear to be two categories of interested persons who would find this book of exceptional value: the student of fisheries, and the technicians. Those of us concerned with the training of fisheries biologists welcome a compact treatment of these aspects of the biology of fishes and it is probable that Dr. Davis' book will find its greatest reception among the students.

As the title implies, the book consists of two parts. The first part, consisting of 178 pages, is devoted to trout hatcheries, propagation and foods of trout, propagation of grayling, pikeperch, pike, muskellunge, black basses and other centrarchids, channel catfish, minnows and suckers, construction and operation of fishponds, and the farm fish pond.

Of the few minor objections which this reviewer found to the book, one is the extent of treatment of the preceding topics; the coverage of the salmonid fishes is somewhat out of proportion to that accorded the other fishes. It is believed that in view of the encompassing scope of the title of the book and the available literature, the discussion of the other fishes might have been more intensive.

The second part, of 115 pages, is concerned with parasites and diseases. It is in this section that specialists will doubtless find fault with the rather general treatment of an abbreviated list of parasites and diseases. However, the value of having available a reference such as this far outweighs such objections.

Seven appendices are devoted to the construction of apparati such as a drip incubator, a siphon egg picker, and the circular pool, and to methods of daphnia culture and control of external parasites. A bibliography of over 300 citations contributes considerably to the value of the book, especially as source material in parasites and diseases of fishes.

This reviewer was somewhat concerned by the paucity of illustrations, particularly in those sections treating fish ponds and the various species, where illustrations would greatly enhance the format and reduce verbiage.

Nevertheless, the efforts of Dr. Davis in making available a book such as the one under review are most certainly to be highly commended. The book will be a valuable addition to the library of anyone who has some interest in fishes.—GEORGE K. REID, JR.

Furs, Glamorous and Practical. By Frank G. Ashbrook. D. Van Nostrand Co., N. Y. 88 pp., illus. 1954. $2.95.

This little book, that can be read in two hours, and digested in twice that time, covers the genealogy of a fur coat, the techniques employed in dyeing furs, styling and all matters that are part of processing a pelt from trapping to wearing. The author includes important facts about furs, little known to many trappers and fur biologists. He discusses data on the wearing qualities of furs, a guide to purchase, the care of a fur garment and other matters that are of concern to both the fur buyer and the seller of fur garments. The glossary of terms used in the trade includes, in part, some that are of interest to the raw fur buyer.

While much of the information has appeared sporadically in trade journals and popular magazines, the inclusive data summarizes the field in matchless style. Ashbrook knows the fur industry like few others. This little book is recommended to all those interested in fur animals. They will gain new insight on the final disposition of the animals studied in the field. A knowledge of matters presented here will place the fur biologist in a better position to acknowledge the many queries both trappers and fur buyers so frequently ask.—W. J. HAMILTON, JR.

American Game Birds. By Frank C. Edminster. Charles Scribner's Sons, New York. xx+490 pp., illus. 1954. $12.50.

This volume presents a well organized cross-section perspective of seventeen species of upland game birds, of which three are exotics—Hungarian and Chukar partridges and ring-necked pheasant. The others are the native species generally popular with hunters over the United States and Canada.

The author disclaims any pretense of being an expert on all of them, but documents his citations of research and management work by technicians who specialized on various species.

Principal topics discussed under each species-chapter are Classification, Description, Geographic Range and Distribution, History, Habits, Habitat, Food, Effects of Weather and Climate, Predation, Man's Relations, Productivity and Populations, and Management. Ecological and management aspects receive a highly commendable degree of emphasis. As might be expected of a presentation by a Soil Conservation Service representative, land use influences are stressed throughout.

The author wisely avoids duplication of discussions of general principles and techniques of management applicable to more than one species. Each

such item is treated in a particular species-chapter where it may have reached a high degree of development or usefulness. For example, a discussion of hunting cooperatives appears only in the chapter on the pheasant; techniques of water management on arid lands appears in the chapter on the California quail. In the pheasant chapter there is an excellent discussion of farm planning in relation to pheasant production. There follows a close parallel concerning bobwhite quail.

A series of life equations points up the annual cycle of 100 birds of each of a number of species. Some readers might accept these too literally, but if considered as generalized trends, they provide an acceptable suggestion of population dynamics.

It is of interest to note that, for some species, unpublished data on hunter success, age and sex ratios and the like have been drawn from state Pittman-Robertson reports. Mr. Edminster deserves praise for thus including more specific and up-to-date discussions than are usually found in "general" texts.

It is re-assuring, when reading the chapters on familiar species, to find that almost every preconceived question is adequately answered. In short, the material appears to be current and valid, and its treatment is sound. There are omissions of local situations that depart from general conditions, but this is something that cannot be avoided. Controversial subjects, such as predator control, refuges, and artificial propagation are not ignored, but the treatment reflects a distinctly biological attitude.

The illustrations, comprising 99 plates and 30 figures, have been carefully chosen and well done—a pleasing attribute which has not obtained in many recent major wildlife publications. As a text for the student and as a practical reference for the technician, AMERICAN GAME BIRDS is excellent. It is unfortunate that the price must be so high.—W. C. GLAZENER AND O. H. HEWITT.

Rovfuglene og Viltpleien (Predatory birds and game conservation.) By Yngvar Hagen. Gyldendal Norsk Forlag, Oslo 1952. 603 pp., 114 figures. Norwegian text. Price (bound) 50 Norw. crowns. (= approximately $7.00).

More than twenty years ago the author began studies on cyclic species of Norwegian game birds. Feeling a need for information on the significance of predation in relation to game bird populations he turned his attention to the birds of prey. In Norway, as in this country, the birds of prey were being reduced by hunters in their indiscriminate campaign against "vermin." The Kite, Honey Buzzard and Osprey, all harmless to game species, had been brought to dangerously low levels. To assemble facts with which to combat this practice Mr. Hagen began, in 1934, a systematic field study of the hawks and owls. The present book presents the results of his studies on the 25 species of predatory birds which breed in Norway.

Each species is described in detail and data are presented on occurrence, distribution, migration (if present), breeding habits and food. The information on breeding habits and food is the most extensive.

These monographs of species form the bulk of the book. General introductory chapters describe the persecution of predatory species, the general ecology of predatory birds and the relationships between predators and small rodents during cyclic fluctuations in populations. To aid in identification of specimens a table of characters, including body weight, eye color and other "fresh" qualities are used.

Norway has many species of predatory birds in common with North America. Most are subspecifically different in the two areas. The Gyrfalcon, Peregrine Falcon (Duck Hawk), Merlin (Pigeon Hawk), Goshawk, Rough-legged Hawk, Golden Eagle, Marsh Hawk, Osprey, Snowy Owl, Hawk Owl, Great Gray Owl, Long-eared Owl, Short-eared Owl and Tengmalm's Owl are found in both Norway and North America.

Of special interest are the author's findings concerning the relationship between micro-rodent population cycles in boreal latitudes and the reproductive success of predatory birds. The author studied five species (Rough-legged Hawk, Marsh Hawk, Merlin, Kestrel, Short-eared Owl) over a period of eight years in the Dovre Mountains in central Norway. As might be expected the predators reared the largest broods in "mouse years" while many made no breeding attempt at all in years of low mouse populations. When the drop in rodent populations occurs after the hawks and owls have started to breed very few young birds are raised. Most perish, apparently from starvation. For example, in 1946 there was a drop in rodent numbers after nesting had begun. Out of seven clutches of Rough-legged Hawk's eggs only two young were raised. In the favorable year 1941 however, 22 young were raised from nine nests.

During periods of low food supply cannibalism may occur. The author has proof of cannibalism in the Goshawk, Merlin, Kestrel, Rough-legged Hawk and Marsh Hawk. It is during periods of low rodent populations that predatory birds take the heaviest toll of birds for food.

The fluctuation of the Merlin, which preys almost exclusively on birds, in accordance with the rodent cycle is explained by the author as due to a temporary, but strong, competition between the several species of predators during the low point in the rodent cycle. Thus, according to this explanation, the effect of low mouse populations on mouse-eating species is direct and forces them into competition with the bird-eating species which respond to the competition and hence indirectly to the mouse population cycle.

The species accounts are followed by several general chapters, one of which treats the results of food analyses. These include 11,221 records of vertebrate prey. Approximately 1000 game species are represented including 724 grouse, 76 ducks, 54 woodcock

and snipe and 151 hares. In addition, apart from 13 instances of cannibalism, they include 109 predators which were taken as prey. These range from Red Fox, Snowy Owl, Gyrfalcon and Rough-legged Hawk to the Weasel and Pigmy Owl.

The small rodents, however, constitute the bulk of the prey, comprising 6917 specimens or 62% of the total. Among these *Microtus oeconomus* and *M. agrestis* occur most abundantly whereas the Norwegian Lemming is represented by the surprisingly small number of 517. It appears that *Lemmus* is not such a dominant prey species, at least in Norway, as has generally been thought. Hagen found that both hawks and owls seemed to prefer other microtines, often killing lemmings but not eating them.

In the final chapters attention is given to the fluctuations in the populations of grouse and ptarmigan in Norway over the past century or more and game conservation problems are discussed against the background of the author's predator-prey investigations.

Other reviewers (Ibis, **1952**(4) and British Birds, **46**(3)) have pointed out that the author might well have made more use of non-Scandinavian literature sources.

The foregoing review has been prepared primarily from an English summary provided by the author. —CHARLES G. SIBLEY.

This Is Dinosaur: Echo Park Country and Its Magic River. Edited by Wallace Stegner. Alfred A. Knopf, Inc. New York City. 97 pp., 47 photo., 1955. $5.00.

At this critical period in the existence of Dinosaur National Monument, and perhaps even in the existence of the whole National Park system, it is indeed most welcome and opportune to have this fine book appear. Though the editor states that the various contributors "have not chosen to make this book into a fighting document," each photograph, each paragraph, each page, by virtue of telling of the beauty and value of this magnificent canyon country, is as loaded with ammunition as a caisson. All but two of the contributors even unlimber their shooting irons and take some intentional, well-aimed shots at the proposed Echo Park and Split Mountain dams. "Fighting document" it may not be, but it certainly is not a peace treaty with the Bureau of Reclamation or with others who would trade kilowatts for top quality recreation and inspiration which is unique in North America.

An historian and novelist, a geologist, a mammalogist and field biologist, a conservationist, an anthropologist, an experienced fast water boatman, a state legislative representative, and a publisher, outdoormen all, have contributed sections of this book. They have ably presented from first hand experience various facets of this jewel in the National Parks' crown.

One of the most impressive chapters in the compilation is that one made up entirely of photographs, 47 in all including the title page. Seven of these are full page color plates which have been expertly chosen as portrayals of the scenic splendor and spirit of the canyons

Sections of the book range from the geologic history of the area to an enumeration and brief description of past and present flora and fauna. One of the most engrossing chapters tells of the boatmen, and their boats, who succeeded or failed in running the Green and Yampa Rivers. The various contributors include: Wallace Stegner, Eliot Blackwelder, Olaus Murie, Joseph W. Penfold, Robert Lister, Otis "Dock" Marston, David Bradley, Alfred A. Knopf.

There is little in the excellent contributions with which to take issue or which merits criticism. Stegner's example of man seriously upsetting the balance of nature by destroying downed timber in a forest rather taxes the imagination and smacks of armchair conservationism. If there is any criticism of Bradley's beautiful section "A Short Look at Eden," it might be that, apart from the river rapids, he has created an impression of tranquil grandeur. Many of us cherish Dinosaur partly because of its siren-like allure which has a potential for danger and relentlessness should the pilgrim become careless.

If you have visited the Green and Yampa canyon country; if you plan to visit it; if you will never visit it at all, but rejoice in the fact that there is an unspoiled wilderness astride the Utah-Colorado border which helps to keep alive the spirit of adventure in America,—you will enjoy this book and want a copy for your bookshelf.—LAWRENCE S. HAMILTON.

BRIEFER ARTICLES

SKIN TUMORS ON SQUIRRELS

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and

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During 1952, Kilham, Herman and Fisher (1953) observed multiple cutaneous tumors on six gray squirrels (*Sciurus carolinensis*) from Maryland. These had the gross appearance of fibromas and histologically resembled Shope's rabbit fibroma. Cross-neutralization tests provided immunological evidence that further related the squirrel and rabbit fibromas. Intracutaneous inoculations yielded successful transfers to woodchucks (*Marmota monax*) and domestic rabbits (*Oryctolagus cuniculi*).

No previous evidence of the occurrence of fibromas or skin tumors on squirrels has been found in available publications. However, in checking unpublished data in collections of the Patuxent Research Refuge and the New York Wildlife Research Laboratory, the authors have uncovered a few more cases which suggest that this infection probably has a higher incidence and wider geographical distribution than heretofore considered. A gray squirrel collected at Washington and Lee University, Lexington, Virginia, in early June, 1936, contained numerous nodules on the skin of the extremities, head and abdomen. Multiple skin tumors were observed on a gray squirrel shot in North Carolina in April, 1938. Dr. D. Coburn diagnosed as fibroma multiple skin tumors on a gray squirrel collected in Aquasco, Prince Georges County, Maryland in May, 1942. Three infected gray squirrels have been collected in

FIG. 1. Naturally occurring fibromas on gray squirrel. From *Kilham, Herman* and *Fisher*, 1953.

New York state: an immature male, shot on November 8, 1940, in Whitehall, Washington County, with tumors over lower part of body; a female, probably immature, shot on October 24, 1948, in Owego, Tioga County, with tumors covering shoulders and forelegs, both sides of the face, and scattered over abdomen and flanks; and, a male shot in October or November, 1950, near Lockport, Niagara County. An immature male gray squirrel, killed near Leopold, Doddridge County, West Virginia, on October 10, 1947 was covered with over 100 skin tumors scattered over most of its body. In all of these animals gross appearance of the lesions was similar to that reported from squirrels by Kilham, *et al.* (Fig.1).

In September, 1938, a porcupine (*Erethizon dorsatum*) collected at Warren, Pennsylvania, exhibited numerous skin tumors on the extremities. From microscopic examination of sections of these tumors, Dr. D. Coburn made a diagnosis of fibroma. Similarly, skin tumors on a fox squirrel (*Sciurus niger*) collected in Charleston, West Virginia, in November, 1940, were diagnosed as fibroma.

In view of the limited information available on distribution of skin fibromas on gray squirrels and other mammals, additional evidence that may be obtained by wildlife biologists on this infection should be reported.

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THE USE OF AUDITORY STIMULI FOR FLUSHING RING-NECKED PHEASANTS,[1]

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The destruction of incubating ring-necked pheasants by the mowing machine is a major problem in the management of this species. On four sections of land in Wood County, Ohio, Leedy and Dustman (1947) found that approximately two-thirds (64.2 per cent) of the pheasant nests were situated in meadows during the period 1939–1941. Warvel (1949) reported that nearly three-fourths (71.4 per cent) of the incubating pheasants in meadows are sometimes killed or crippled in the first nesting attempt of the season during day-time hay mowing operations. Studies by Seubert (1952) have shown that, if the incubating hen pheasant can be saved from destruction when the nest is destroyed during this first nesting attempt of the season, a second nesting attempt can very often be expected.

Flushing bars (English, 1934; Warvel, 1949) have been used to a limited degree to mitigate this loss. Unfortunately, the flushing bar imposes some inconvenience on the mowing operator, and this fact tends to restrict the extent of its use. In addition to the inconvenience inherent in its operation, the flushing bar is only partly effective in reducing casualties among incubating pheasants. Warvel (1949) reported that casualties among incubating pheasants were reduced from 71.4 per cent when the bar was not used to 47.4 per cent when the bar was used. Roughly, of every three casualties resulting from day mowing operations, one can be averted by use of the flushing bar. The flushing bar has become increasingly ineffective with the increasing speed and increasing use of tractors for mowing.

The appalling loss of pheasant breeding stock in connection with hay mowing operations seemed to indicate the need of a quest for a more effective and efficient method for averting this destruction. A possible solution which had not yet been examined involves the use of an auditory device which will elicit the flushing response in incubating pheasants. Consideration of this possibility gave incentive to the present study.

If a specific sound can be isolated and found to be effective for frightening incubating pheasants from their nests, the sound can most probably be discovered by a program involving detailed observations of the birds under controlled conditions which are as near as practicable to natural conditions. Detailed observations of minor responses to different sound stimuli might yield a clue when the investigator is on the right track, even though a specific sound does not fully satisfy the requirements.

[1] This paper is a contribution from the Ohio Cooperative Wildlife Research Unit: U. S. Fish and Wildlife Service, Ohio Division of Wildlife, Wildlife Management Institute, and Ohio State University cooperating.

EQUIPMENT AND TECHNIQUE

An Ekotape sound recorder and a Grason-Stadler audio-oscillator were used to present sound signals to incubating ring-necked pheasants. The sound-producing equipment was placed in an observation blind from which detailed observations of the birds' responses were made. In each case, the blind was near enough to the incubating bird that it was possible for the observer to note such a detailed response as the rate of movement of the nictitating membrane. The speaker for the sound equipment was placed outside the blind five to ten feet from the nests, and it was aimed toward the nests. A heavy-duty extension cord connected the sound equipment with a 115-volt Kohler portable generator which was transported in an automobile to within 200 feet of the nest. The generator motor noise at the nest was so slight that it was not picked up in sound recordings. A Hermon Hosmer Scott sound level meter was used to measure intensities of the sounds at the approximate position of the birds' heads. The microphone of the sound level meter was placed in position near the birds by dangling it from its cord, and this was always done without flushing the birds.

Some of the sounds could be heard one-fourth of a mile or more from their source. The intensities of the sounds presented were measured in decibels above the average background noise. The reference level used was 0.0002 dynes per square centimeter.

The field work on this project was conducted at the Olentangy Wildlife Experiment Station in Delaware County, Ohio. A population of brailed pheasants was maintained here by the Ohio Division of Wildlife in a 40-acre enclosure in connection with a study of pheasant production under semi-confined conditions. Unfortunately, the number of birds contacted was restricted by the design of the pheasant production study being conducted in the area. Additional birds were contacted with the sound stimuli only as it was demonstrated that nest desertions did not result. Seven different incubating birds were exposed to tests for responses to auditory signals.

It must be noted that only brailed birds were subjected to the auditory tests. The objective of investigating the responses of wild birds was not achieved during this study. However, it is felt that the fundamental reactions of pheasants to auditory stimuli should be essentially similar whether or not the birds are brailed.

Testing of incubating birds which readily flushed upon the approach of disturbance was avoided. The seven pheasants which were contacted with sound tests could be quietly approached and touched without flushing. No test was made with a bird on a newly established nest.

AUDITORY STIMULI TESTED

Tape recordings were made of several different sounds which it was thought should have a disturbing influence on incubating pheasants. In the following list of sounds, the numbers in parentheses indicate decibels above the average background noise with which the sounds appeared at positions very near the birds' heads: flushing call of ring-necked pheasant (44–48), distress squeal of captive hen (38–42), alarm note of cock pheasant (30–34), distress peeping of pheasant chick (26–29), barking of collie dog (47–51), imitated hooting of barred owl (50–55), imitation of screech owl (48–52), squeal and chatter of captive weasel (48–51), beating on 50-gallon steel drum with hammer (50–54), sounding of automobile horn (53–58), "pish" emission of air from human mouth (42–46), rewinding of recorder tape (40–44), noise from hand-operated air raid siren (52–56). A variety of sounds were also generated with the audio-oscillator. These were of frequencies ranging from 20 to 20,000 cycles per second and of intensities ranging from 26 to 36 decibels above the background noise. The sounds were presented both continuously and intermittently.

VISIBLE RESPONSES TO SOUND STIMULI

Incubating ring-necked pheasants readily responded to sound stimuli leading to behavior which did not counter the incubating impulse. Two incubating hens quickly searched beneath themselves when the distress peeping of a pheasant chick was given. When the chick could not be found in the nest, one hen backed off the nest as she seemingly continued to search for the chick. At such times, the birds searched beneath themselves rather than to explore in the actual direction from whence the sound came. Thus, this sound could not be used to lure the hen away from the nest.

Much less marked responses were given to sounds expected to frighten the birds. Such responses usually consisted only in a cessation of panting, a slight acceleration in the movement of the nictitating membrane, and in a raising or lowering of the head or turning it toward the source of the noise. One bird tilted its head sideward and seemed to peer overhead when it was exposed to the imitated hooting of a barred owl. The birds usually were panting throughout the tests except for a short interruption in this activity when each new sound was introduced. Panting was always resumed after the new sound had continued 20–50 seconds. On no occasion was a bird frightened from its nest by a sound alone. The birds several times calmly closed their eyes as though sleeping when a high intensity sound (56–58 db.) was being presented.

Of the various sounds generated with the audio-oscillator, the birds showed slightly greater sensitivity to those of about 800 cycles per second. This sensitivity was indicated by slightly more pronounced movements of the head. The difference in sensitivity was of a negligible magnitude. Dowling (1952) also noted that pheasants which he was subjecting to auditory acuity tests were slightly more disturbed by tones of 750 cycles per second than by other tones sounded.

INCIDENTAL TESTS WITH AN AIR RAID SIREN.

Early in the season, before the design of the field experiment was formulated, some preliminary tests were made with a hand-operated air raid siren. Five incubating birds were approached by the investigator when operating the siren. An assistant observed the behavior of the birds from the greatest distance at which they could be clearly seen. Five birds were thus contacted, of which four flushed at distances ranging from 6 to 48 inches. A fifth bird remained on the nest until and after the air raid siren was actually held against her head. Her eyes were closed for a short interval when the air raid siren was in operation and touching her head. She later flushed when quietly approached and the writer's hand was approximately eight inches from her head. The intensity of sound generated by the siren was 64 decibels at a distance of two feet from the instrument.

SUMMARY

Observations were made from a blind on the responses of incubating ring-necked pheasants to various auditory stimuli. A number of natural sounds, presumed to be of a disturbing nature, were recorded and presented to the nesting birds with the use of a tape recording machine. Several nesting birds were also exposed to a variety of tones which were generated by an audio-oscillator. The incubating birds readily responded to several sounds which did not counter the incubating impulse. They quickly placed their heads beneath their breasts, as if searching for a chick, when the distress peeping of a chick was presented. One hen tilted her head sideward as if searching the sky for an avian predator when exposed to the imitated hooting of a barred owl. The responses to such sounds as the distress squeal of a hen pheasant and the squeal of a weasel consisted only of slight movements of the head or a slight acceleration in the movements of the nictitating membrane.

Freezing immobility sometimes occurred when the birds were exposed to a sound of about 60 decibels above the average background noise. There was a slightly greater sensitivity to sounds of about 800 cycles per second than to other sounds, but no indication was encountered that any auditory signal might have value for frightening ring-necked pheasants from their nests ahead of the mowing machine.

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A MODIFIED SHOREBIRD TRAP FOR CAPTURING WOODCOCK AND GROUSE

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In connection with woodcock management studies initiated by the Pennsylvania Game Commission in 1951, it was believed necessary to have information concerning the movements of both local and migratory birds. To accomplish this, an attempt was made to capture and band woodcock during the spring, summer and fall seasons. Techniques for making single captures of males during the spring had been developed, but no satisfactory methods existed for making multiple captures in summer and fall.

Liscinsky experimented with various types of traps and was able to capture a number of woodcock during summer and fall. Bailey successfully trapped juvenile and adult grouse, using a similar trap with only minor alterations. The trap, although still in the experimental stage, may be of use to other game technicians.

Basically, the trap is a modification of the shore bird trap originally designed by Low (1935. Methods of trapping shore birds. Bird Banding, **6**: 16–22) after the pattern of Lincoln's three-leaf clover dove trap. The major obstacle in using the trap as originally designed was its bulkiness. Because woodcock trapping sites are generally in dense covers some distance from roadways, it was desirable to have the trap as compact as possible. An attempt was also made to reduce the cost of construction.

Various modifications in size, shape and other aspects were tried, but only the trap which proved most efficient, compact, and economical will be described. A basic pattern is presented.

The body of the trap consists of two, 1′ x 9′, sections of 16-gauge, 1″ poultry wire, and one, 3′ x 6′, piece of ½″-mesh cord netting. The wire is staked into position as illustrated in Figure 1, and thus forms the wall of the main compartment. A finer gauge wire may be used but more stakes will be required to keep it in the upright position. The cord netting (used in place of wire to minimize scalping) is placed over the wire to form the roof of the trap. The four corners of the netting can be tied to stakes and/or wired to the compartment wall to prevent captured birds from escaping. The width of the funnel-like entrance through which the birds must pass measures 2½″. This width can be adjusted by the same stakes which hold the compartment wall upright. By placing these stakes several inches back from the end of the entryway, a spring-like tension is produced which adds to the one-way effect of the entrance.

To facilitate handling and banding, and to reduce the chances of scalping and predation, a gathering cage (6″ x 12″ x 24″) is attached to the main portion of the trap (Fig. 1). These cages are made of ½″-mesh hardware cloth. The top, bottom, and sides of the cage are made from one piece of hardware cloth 24″ x 36″. The front end of the cage is left open but the back end is enclosed with the same material. Two one-way swinging doors are hung midway along the ceiling of the cage. Twelve-gauge, 1″ x 2″ mesh wire was used to make these small doors. Only enough horizontal cross wires were left on each door to insure firmness. A heavy wire rod (10-gauge) is inserted 1½″ above the floor and 11″ from the rear of the cage. This rod is placed in such a manner as to prevent the hanging doors from swinging back, thus holding captured birds in the rear section. A small doorway (4½″ x 5″) is cut into the rear of the cage to permit removal of the birds. The hardware cloth can be cut and shaped to make grooves for a sheet-metal sliding door.

The handling cage is attached to the main part of the trap after an opening has been made in the compartment wall. The wire from this opening should not be completely removed, but rather it should be left partially attached and bent in such a manner as to help direct the bird into the handling cage.

To complete the set-up, lead fences are erected. These can be made from 20-gauge, 1″ poultry netting. For trapping woodcock, it was satisfactory to

FIG. 1. Woodcock and grouse trap in place.

split an 18″ width and erect a 9″ fence. A taller fence was found necessary for grouse. The length of the lead can be varied according to the situation, but for all practical purposes a 50′ length is probably maximum for woodcock, and a 30′ length for grouse. The fence is fastened to stakes at 8′ or 10′ intervals. The first stake should be at least 6″ from the end of the lead at the trap. The number of lead fences necessary for best results will vary according to the trap site and other factors.

The cost of materials for one woodcock trap is approximately $4.00, and about $6.00 for one grouse trap. All the materials for one trap, minus the gathering cage, can conveniently be carried in a medium-sized pack sack. Less than four hours is required to erect the trap. Bailey cut this time in half by simplifying the gathering cage and by using the same gauge and width of wire throughout. One 150′ roll of 20-gauge wire was taken into the field uncut. Because of the standardization of materials and the simplified gathering cage, it was possible to carry out all phases of construction at the trapping site.

The proper location of the trap and lead fences is the most critical factor in successful trapping. The sites most frequently inhabited by woodcock during the hot summer and fall days are moist depressions or gullies shaded by low trees or shrubs. It is there that woodcock concentrate to feed and to escape the heat. When trapping deep gullies, it is best to place the trap in the gully and run lead fences out along the bottom. When trapping where there are a number of shallow gullies or depressions place the trap in the center and run at least two leads out to intersect several depressions. Clearing of vegetation for a few inches along each side of the leads aids in capturing woodcock, but not necessarily grouse.

Some alterations in trap structure and in trapping technique are necessary when trapping grouse, but essentially the design of the trap and the placement principle are the same. It should be emphasized at this point that the trap was designed for the purpose of capturing complete broods of juvenile grouse. Nevertheless, several adult grouse were captured.

Bailey found it expedient to make the following changes. The height of the main compartment and the lead fences, as well as the gathering unit was increased to 18″. Twenty-gauge wire was used throughout. A simplified gathering unit that proved quite efficient was developed. It consisted of an additional section of wire of the same gauge and height as the main portion of the trap. This section was formed into a small circular unit approximately 2′ in diameter, and attached to one side of the trap in a fashion somewhat similar to that described for the woodcock trap. Captured birds were removed by lifting a corner of the roof netting.

Grouse trapping sites were selected only after careful observation of grouse brood territories. Those traps in which the greatest success was realized were placed near an edge, such as trails or small cuttings that served as feeding or loafing areas for the chicks. Lead fences were constructed from the trap entrance to the border of the cutting or trail to intercept the birds.

The effectiveness of this type of trap can best be described by giving a brief summary of the results of two seasons of trapping. A total of 61 woodcock (45 new captures and 16 recaptures) were taken during the summer and fall months of 1952 and 1953. Trap success was more than tripled the second year. In 1952, 779 trap-days were expended in trapping 15 woodcock; in 1953, 602 trap days resulted in the capture of 46 woodcock. Improved trap success can be attributed chiefly to judicious trap placement and timing in respect to weather.

Thirty-five grouse (31 new captures and 4 recaptures) were trapped during the summers of 1952 and 1953. Twenty-five were juveniles. During 1952, 212 trap days were expended in capturing nineteen grouse, or 11.2 trap days per grouse. During 1953, the trapping success was markedly lower with 27.1 trap days being expended per grouse captured. Probably the greatest reason for this decreased trap success was the greater dispersal of broods during 1953 and the larger number of multiple captures (four) during 1952. Only two of eleven trap records were multiple captures during 1953.

Traps were usually visited only once daily at the convenience of the investigator. On those few days when woodcock traps were visited twice, no captures were recorded between the 8 to 10 A.M. visit and the 4 to 6 P.M. visit. It seems that woodcock are most often captured either early in the morning or late in the evening, but sometimes mid-day. Grouse broods may be captured at any time of day.

Traps are effective in one spot as long as the birds are inhabiting the particular cover in which the trap is set. In the case of woodcock, as long as the particular site provides protection from exposure and a reasonable supply of feed, the trap site will be productive. Soil moisture appears to be the critical factor in providing suitable feeding areas which often become very restricted during drought periods. Some sites provide these requirements over a longer period of time than others. For example, one trap site yielded 21 captures in 81 days of intermittent trapping between July 14 and November 9. Another trap, operated for about the same amount of time yielded only 4 birds.

The greatest success was realized in trapping grouse broods when the trap was set at the edge of an open area such as a roadway or cutting. Field observations of brood use of the area should indicate when the trap should be removed and reset in a different location. Several traps yielded more grouse than others; however, this was mostly due to multiple captures when from 6 to 8 birds were trapped at the same time. The incidence of trapping was just as great in several of the other traps but multiple captures were not so large. Since there is always the chance of capturing the entire brood, the incidence of trapping should be given prime con-

sideration when attempting to determine the comparative value of two trap sets.

Numerous other animals were taken during these trapping operations. While trapping woodcock, Liscinsky took 18 ruffed grouse (17 juveniles, 1 adult), 1 song sparrow, 9 chipping sparrows, 2 white-throated sparrows, 13 wood thrushes, 1 brown thrasher, 11 catbirds, 3 robins, 2 worm-eating warblers, 1 virginia rail, 2 sharp-shinned hawks, 35 wood turtles, 3 painted turtles, 15 cottontail rabbits, 5 opossums, 1 red squirrel, 1 woodchuck, and an 8-inch sucker. While trapping grouse, Bailey captured 2 robins, 4 wood thrushes, 15 oven birds, 1 cottontail rabbit, 3 gray squirrels, and 2 box turtles.

Four cases of predation on woodcock were observed in trapping operations. Mammalian predators were guilty in all instances. Entrance to the trap in at least three of the cases was made by digging underneath the main compartment wall. All the kills were made in the main compartment. Apparently the birds had not been captured long enough to work their way into the more predator-proof handling cage. No incidence of predation on trapped grouse occurred.

In conclusion it should be remembered that these initial tests were not carried out in areas of high populations, but rather in areas typical of some of central Pennsylvania's woodcock and grouse coverts. There is reason to believe that a larger catch could be realized in areas of greater woodcock and grouse abundance and especially in concentration areas.

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NOTES ON ALBINISM IN THE EASTERN WILD TURKEY

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Several authentic reports of albino and partial albino wild turkeys (*Meleagris gallopavo sylvestris*) in West Virginia have been received in recent years. Most unusual of these was a report of five albinos seen by a hunter near Bartow in the fall of 1952. Apparently, all five of these survived until the 1953 hunting season, as Mr. Isaac Starks of Bartow reported killing a partial albino gobbler, weighing twenty pounds, from a flock of five albinos. W. F. Rexrode, Conservation Officer, investigated this kill and reported the gobbler had white wings and a gray body. So far as is known, none of the remaining four albinos was killed during the 1953 season.

In the fall of 1952, Gail Swecker, Wildlife Manager, reported seeing a pure white turkey in a large flock of normally colored ones on top of Cheat Mountain. No further report of this turkey was received.

Conservation Officer Fred Trainer reported seeing a pure white turkey hen near Minnehaha Springs, Pocahontas County, a few years ago. Though Mr. Trainer saw this turkey on several occasions, he does not know what became of it.

In October, 1953 the writer observed at close range a nearly pure white juvenile turkey in the company of a normal turkey, also juvenile, on top of Black Mountain five miles west of Marlinton. This albino had a few flecks of pink on its flanks and wings. No additional record of it was obtained although the area received heavy hunting pressure the following open season.

These are believed to be cases of natural albinism as no domestic white turkeys are known to exist in the areas where the observations were made.

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TWO RECORDS OF TURKEY BROOD SURVIVAL AFTER DEATH OF THE HEN

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An interesting example of predation, in the light of subsequent events, occurred in June and July, 1953 on the Rimel Game Management Area, Pocahontas County, West Virginia. On June 29, Gerald Finney of the U. S. Forest Service, Wildlife Managers Dennis Dean and Arlie White, and the writer flushed a hen turkey with nine quail-size young from a large meadow. A week later, when the meadow was being mowed, evidence was noted of the kill of an adult hen turkey by a predator, presumably a fox. The hen's carcass had been dragged across the field and into the woods to be eaten. It was immediately assumed that this was the same hen that had been flushed with a brood of nine the week before. No evidence of young turkeys was noted in the vicinity at the time the kill was discovered.

The above incident was entirely forgotten until

July 30. On that day Arlie White and the writer observed eight young turkeys not over 400 yards from where the brood of nine had been seen and the hen killed. The eight poults were not accompanied by an adult. They were under observation for about ten minutes and there is little likelihood of error in assuming that these were the poults of the hen that had been killed. The young had made normal growth.

This brood of eight poults was seen regularly throughout the remainder of the summer until the week before the hunting season opened. None of them was observed later nor were any reported seen by hunters during the season. In view of the fact that these young turkeys did not possess a normal fear of man and automobiles, it may be that they fell victim to a poacher.

Clay Heitz, Wildlife Manager, Tucker County, has reported to the writer another instance of brood survival with no adult turkey present to tend or shelter the young. Mr. Heitz and numerous other persons in his area observed this brood several times during the summer of 1953. In no instance was it accompanied by an adult turkey.

The summer of 1953 was hot and unusually dry. Presumably, such conditions may have been conducive to the survival of the poults.

It came as a surprise to the writer that wild turkey poults are capable of surviving after death of the mother hen in early summer.

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NOTES ON REPRODUCTION AND RATE OF INCREASE OF RACCOONS IN THE POST OAK REGION OF TEXAS[1]

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Effective management or controls can be maintained in populations only if we have an understanding of reproductive patterns and rate of increase of the species. The data here presented are from raccoons collected in the uplands of the Post Oak Region of Texas during 1950–51.

Both morphological and ecological data were used in the analysis. Reproductive tracts of all raccoons collected were examined to determine condition of ovarian follicles and scar tissues, presence or absence of placental scars and embryos, and presence or absence of sperm.

Thirty-seven female and 34 male raccoons were examined. In addition, three one-year-old penned animals (one male and two females) were checked for reproductive activity.

Ovaries as Indicators of Reproduction

Ovaries were examined for signs of breeding activity. In January, two of 10 females examined possessed Graafian follicles. Two others had developing follicles that had not matured. This suggests that not over 20 per cent of the population sampled would have bred in January. Since the first Graafian follicle was reported on January 16, it appears that breeding may not begin until the last half of January.

In February, of six females examined, two had Graafian follicles and one had developing ova. If the January and February data are combined, and it is assumed that the female with Graafian follicles and those with developing follicles bred within the period, then 43.7 per cent of the female population sampled had bred by the end of February.

Stuewer (1943) found that mating occurred from the first week in February through the first week in March in Michigan raccoons. Hamilton (1936) stated that mating occurred in Ohioan raccoons during late January and early February. Whitney (1932) reported mating in New England raccoons in the last week of January. Davis (MS) stated that breeding begins in February and continues into the first week of March in Texas.

Only three females were trapped during March and all possessed corpora lutea of pregnancy.

The ovaries of one female examined in April possessed Graafian follicles. This indicates that breeding can occur as late as April. Since ovulation normally occurs early in the year, it suggests that raccoons possibly have a polyoestrous cycle and this female did not conceive during an earlier oestrum. Whitney (1932) stated that occasionally a female raccoon in New England skipped the winter mating cycle and mated in the spring. Stuewer (1943) reported a late May litter, probably the result of a second oestrum.

Six females were collected in April. Two possessed corpora lutea. Two possessed corpora albicans; one of these was suckling a litter. The other two showed no signs of breeding.

Corpora albicans were seen on the ovaries during May and June, but the uteri were more reliable organs for interpreting breeding behavior during these months.

[1] Contribution of the Texas Cooperative Wildlife Unit; Texas Game and Fish Commission, Texas Agricultural and Mechanical College, U. S. Fish and Wildlife Service, and Wildlife Management Institute cooperating.

UTERI AS INDICATORS OF REPRODUCTION

Uteri were examined for embryos and placental scars. Five uteri contained embryos and 19 possessed placental scars.

The earliest recorded date of pregnancy was March 18, when the embryos had a crown-rump measurement of 9.8 mm. Embryos of the same size were taken from a female March 26. Another female taken March 26 had embryos with an average crown-rump measurement of 60 mm.

Two pregnant animals were trapped in April. One of these had almost completely resorbed one of three embryos.

The earliest date of birth, as indicated by postpartum females, was April 30. A litter of three found in a den on May 16 was estimated to be about 35 days old, according to growth characters outlined by Hamilton (1936). This indicates that they were born in early April. Stuewer (1943) reported the majority of young were born during the first half of May in Michigan.

Placental scars remain as dark pigmented bands. They become less distinct as ovarian activity increases, and disappear by the time the follicles are mature. (The pigment disappears when tracts are preserved in formalin.) Sanderson (1950) stated that placental scars were evident in January and would possibly show even after a second brood.

Forty per cent of the one-year-old females collected had produced litters. Stuewer (1943) found at least 53.6 per cent of the females produced litters during the first year. Pope (1944) reported both male and female raccoons mate in captivity during their first year.

TESTES AS INDICATORS OF BREEDING

Testes of 34 male raccoons were checked for sperm. Sperm were present when the vas deferens of the epididymis showed as a distinct, coiled tube.

Twenty per cent of the one-year old males trapped during this study possessed sperm. Bennett and Nagel (1937) observed seven males from birth; one bred successfully the first year. Pope (1944) reported males breeding during their first year, but Stuewer (1943) stated that males in Michigan did not mature sexually until their second year. In the present study, a captive one-year old male was not producing sperm. An electrical ejaculator was used to make the test. The apparatus was loaned to the author by Dr. R. O. Berry, Professor of Animal Husbandry, A. and M. College of Texas. He uses this to collect sperm from rams, but has also used it satisfactorily with cats. The principle is to send an electrical current, about 20 volts, through the lumbar region and stimulate the nerves controlling ejaculation.

NUMBER OF YOUNG

The average number of young produced by raccoons was determined by number of embryos, placental scar counts, and number of young in litters.

In five pregnant females, the number of embryos varied from two to four with an average of 2.8. Nineteen females possessed placental scars, the number varying from two to four with an average of 3.63. Only two litters were recorded. One contained four young, the other three. Stuewer (1943) found litter size of Michigan raccoons to be three to seven, with an average of four.

SEX RATIO

The adult sex ratio of 71 animals was 92.5 males to 100 females. Bennett and Nagel (1937) reported a sex ratio of 127 males to 100 females in Missouri, and Stuewer (1943) found a ratio of 108 males to 100 females in Michigan.

RATE OF INCREASE

Rate of increase can be determined by multiplying the number of individuals in an area by a coefficient of birth. The coefficient is calculated by multiplying 3.3, the number of young per adult female (an average of the number of young, embryos, and placental scars), by 45.8 per cent, the percentage of reproductive females in the population. The female sex ratio is 52.1 per cent. Yearlings constituted 20.7 per cent of the total population, thus 10.5 per cent of the population were one-year-old females. Of the yearling females, 60 per cent were not sexually mature; therefore at least 6.3 per cent of the total population of females were nonproductive. This gives a coefficient of birth of 1.5. The fall population, therefore, would be 1.5 times greater than the previous winter. Bennett and Nagel (1937) and Stuewer (1943) arrived at the same figure.

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A TRAPPING TECHNIQUE FOR BAND-TAILED PIGEONS

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Band-tailed pigeons (*Columba f. fasciata*) have been considered difficult to trap. During the period 1942 through 1948 only 118 were banded. Difficulties in trapping, together with low populations, resulted in little being known of their migratory habits. It has been presumed, however, that their over-all migrations are extensive and coincide with short, erratic seasonal migrations to certain regional elevations as food in these areas becomes available.

In order to obtain additional information on pigeon migrations, an intensified banding program, initiated in 1952 by federal and state wildlife agencies resulted in 198 birds being trapped and banded. This article presents information on the construction and use of a simple drop trap which has been utilized successfully in the States of Washington, Oregon, and California.

The trap described herein was first used by members of the Oregon State Game Commission in Tillamook County, Oregon, in May 1950. These efforts resulted in the trapping and banding of 62 birds in three attempts. In 1952, a modified trap was constructed and used near Florence, Oregon, by U. S. Fish and Wildlife Service and Oregon Game Commission personnel who successfully trapped and banded 111 birds. In the following year, the same personnel again utilized the trap in this area to trap and band a total of 391 birds. In May 1953, 212 pigeons were captured in one drop of the trap with a mortality loss of only two birds. Of these, 21 were retrapped birds from previous bandings, making a total of 189 birds banded on that date. During 1953 a total of 852 birds were trapped and banded by the drop-trap method in Oregon, Washington, and northern California.

Best results were obtained by selecting trapping sites in newly cultivated fields near roosting areas. In northern California and southern Oregon, Sitka spruce (*Picea sitchensis*), redwood (*Sequoia sempervirens*), and alders (*Alnus sp.*) are used regularly as roosting cover (Glover, Fred A. A nesting study of the band-tailed pigeon in northwestern California. Calif. Fish and Game, **39**(3), July, 1953).

In constructing the trap, 2″ x 4″ lumber was nailed together to form a 16-foot square. A 1½-inch-mesh net was stretched tightly over this frame and secured to the edges with wood laths. Care was taken to avoid any excessive overlapping or sagging of the net. The birds appeared less disturbed by the net when it was dyed a green or brown color to correspond with the color of the surrounding terrain. To prevent escape the ground was smoothed under each side of the trap until the framework fitted snugly against the ground (Fig. 1).

The edge of the trap facing the roosting area was then raised and a 7-foot pole inserted to hold the structure in a lean-to position. The base of the pole

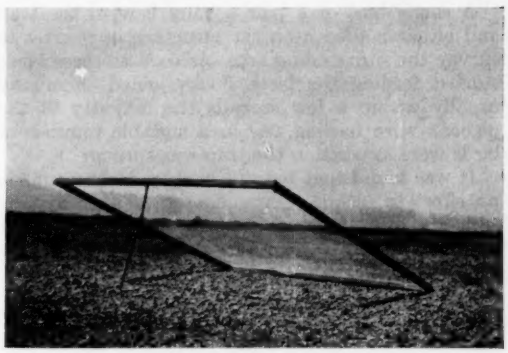

FIG. 1. Trap in position.

was set on a piece of ¾-inch lumber to make a solid foundation but tilted slightly away from the trap to allow it to slide easily as the trap was sprung. A light wire, fastened securely to the base of the supporting pole, was strung to a blind approximately 100 to 150 feet from the trap, which was close to and below the roosting area. Usually this blind was a covered pit camouflaged with natural cover or in a dense stand of brush with natural foliage for concealment. Complete concealment was important as the slightest strange movement startled the feeding birds. The wire, from the pole, was stretched tightly, and securely anchored to a substantial object behind the blind. Slack was taken out of the wire and obstructions between the trap and blind were removed. A handle for pulling the wire was made from a short stick twisted in the wire near the front of the blind with sufficient space allowed for a hard pull when springing the trap. The two forward corners of the trap were secured by a light wire running from each corner diagonally to a stake fastened in the ground. This prevented the trap from being sprung by wind action.

The area beneath the structure was then heavily baited and grain scattered for some distance around the front of the trap. The trap was baited at least once each day with the trapper staying in the area only long enough to put out the bait. Observations made from a distance during the early morning feeding hours provided information on the extent the birds were utilizing the bait, the total number of birds present, and the most desirable time to spring the trap. When it was determined that the birds were accustomed to the trap, arrangements were made for the actual trapping and banding operation.

The trap was baited and the blind occupied during the early morning hours. In all cases some pigeons were flushed while baiting but this apparently did not disturb them sufficiently to frighten

them away, provided patience was exercised in waiting for the birds to return to the trap area, which was usually within 30 minutes to an hour. Occasionally, several hours elapsed before they began feeding.

A single bird or a pair usually flew to the trap and either landed atop the structure or nearby to survey the surrounding area. As soon as these birds started feeding the large flocks joined them and usually within a few seconds the majority of the pigeons were feeding. When a suitable number of birds were in position the trap was sprung.

It was found that pigeons in semi-darkness made no effort to escape. Consequently, as soon as possible after the trap had been dropped, burlap sacks and canvas were spread over the corners and edges of the traps to cover the birds.

The band-tails were removed from under the edge of the trap one at a time by securely grasping them over the back and holding both wings to their sides. It was necessary to exercise extreme care in catching and handling these birds for their feathers were so lightly attached that the slightest struggle caused damage to the plumage.

Following the operation the area in and around the trap was completely cleaned of all feathers since it was found that the pigeons did not revisit the site if feathers were noticeable. Field observations indicated that it was advisable to bait for at least two days before again springing the trap.

Careful construction and use of this trap, in addition to careful handling of the trapped birds, gave excellent results with a minimum of mortality.

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FEATHER MOLT AS AN AGEING TECHNIQUE FOR MOURNING DOVES[1]

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If both the age and sex ratios of a population are known, it is possible to determine the success of survival of the young, juvenile mortality, peaks of breeding and mating, average turnover period, and average longevity (Petrides, 1949). In view of the importance of these data, the advisability of developing an age determination method for the mourning dove is readily apparent. Previous work by Petrides and Nestler (1943), and Pearson and Moore (1940) suggested the use of the juvenal molt of the greater primary coverts as an age criterion.

Determination of age of juveniles by the molt of wing feathers has several advantages. It allows the investigator to sample a wide area by contacting hunters in the field as well as by having them send in wings. It also allows the wildlife investigator to be in the field obtaining other data during the hunting season, because the wings can be analyzed at any future date, providing they are stored under suitable conditions.

FEATHER DEVELOPMENT AND MOLT OF YOUNG

Young doves emerge from the shell practically naked, but by the third day the body is sparsely covered with natal down. By the seventh day the nestling is covered with pin feathers, and on the ninth day these pins break open at the tips and the bird takes on the appearance of being feathered. By the thirteenth day the body is well covered with juvenal feathers. Flight feathers are sufficiently developed to permit short flights, but the tail feathers are very short.

The feathers of juvenile doves are readily distinguishable from those of adults by the pale border at the tip (Pearson and Moore, 1940). The flight feathers of the juveniles have this light border, but after they leave the nest it is soon worn away. The greater wing coverts, however, retain this light tip which is readily apparent until the feathers are shed, one or two days prior to the shedding of the corresponding flight feather. These and the other light tipped feathers give the young bird a "scaled" appearance.

Penned Birds—In order to determine the rate of juvenal molt, young birds of a known age were taken from the nest just before they reached the flying stage. They were placed in outside pens measuring 24 x 24 x 18 inches, and fed identical rations consisting of cracked yellow corn, milo maize, and sunflower seeds. Their diet was supplemented with cod liver oil and grit. Water was available at all times. When first taken from the nest, it was necessary to hand-feed them for a few days, until they learned to pick up their food. The tips of the primary feathers were painted with Testor's Model Airplane Dope to aid in the identification of molted feathers. When possible, the birds were examined every other day and data were taken on

[1] This paper reports a portion of a study made in partial fulfillment of the Ph.D. degree at the Agricultural and Mechanical College of Texas. The study was sponsored by the Texas Cooperative Wildlife Unit; the Texas Game and Fish Commission, Agricultural and Mechanical College of Texas, U. S. Fish and Wildlife Service, and the Wildlife Management Institute cooperating. Special acknowledgment is due the Wildlife Management Institute for a research grant-in-aid.

TABLE 1.—RATE OF MOLT OF JUVENAL PRIMARY FEATHERS OF THIRTEEN CAGED MOURNING DOVES

Band No.	Sex	Date hatched	Primary number 1	2	3	4	5	6	7	8	9	10
			Age (days) when primary feathers dropped									
41-333327.....	M	3-10-49	37	47	59	64	85	103	114	129	154	*
41-333328.....	F	3-10-49	37	50	58	75	90	96	133	152	*	*
48-354815.....	F	3-25-49	33	42	52	63	71	77	98	112	*	*
49-321010.....	F	4-22-49	34	44	53	*	65	81	92	113	*	*
49-321064.....	M	10-2-49	34	39	50	61	73	105**	127**	147**	*	*
49-321059.....	M	10-3-49	46	54	61	68	75	85	98	109	115	130
49-321048.....	F	10-5-49	51	67	83	91	98	105	114	123	133	144
49-321049.....	M	10-5-49	46	52	55	64	72	83	93	106	120	*
49-321060.....	F	10-5-49	36	44	51	61	71	85	103	122	139	*
513-02169.....	?	3-18-50	36	45	52	62	74	80	93	114	*	*
49-321069.....	?	3-6-50	36	54	67	79	90	104	121	*	*	*
49-321085.....	?	4-23-50	38	47	61	70	80	93	107	123	*	*
513-02588.....	F	6-20-50	57	66	77	85	95	108	*	*	*	*

* Feather broken off by bird flying against wire of cage.
** Bird developed a growth on feet and bill.

new feathers coming in and their rate of growth. Notes on any abnormalities were also taken.

A fairly wide variation existed in the age of the caged birds at the time any particular feather number was dropped (Table 1). The general trend was for the magnitude of this variation to increase as the feather number increased. One bird developed a wart-like growth on its feet and bill soon after the molt of primary feather number five. Thereafter, molt of the remaining unbroken primary feathers was considerably delayed. Growth of the new adult primary feathers replacing the molted juvenals consistently averaged five millimeters per day.

Wild Birds—Sixteen birds banded as nestlings were recaptured as juveniles. The date of hatch of each of these birds was known, as nests from which they came were under daily observation. The date on which the last juvenal primary was dropped was determined by measuring the newest adult primary and allowing one day for each five millimeters of growth, the rate of growth exhibited by the penned birds.

The age when feather molt occurred in the wild birds showed somewhat less variation than that exhibited by the caged birds (Table 2).

TABLE 2.—RATE OF MOLT OF JUVENAL PRIMARY FEATHERS OF WILD MOURNING DOVES

Band No.	Date hatched	Primary number 1	2	3	4	5	6	7	8	9	10
		Age (days) when primary feathers dropped									
49-321041	9-15-49	..	..	..	..	..	..	..	..	..	151
49-321412	6-20-50	..	..	..	..	58	..	..	..	..	..
513-02848	7-31-50	..	28	38	..	..	..	..	..	..	..
513-02494	7-18-50	..	..	38	..	..	..	..	..	..	..
49-321359	6-18-50	..	..	..	..	..	..	77	..	..	..
513-02873	7-29-50	..	35	..	..	..	..	..	..	..	..
513-02837	7-25-50	..	..	43	..	..	..	..	..	..	..
513-02813	7-22-50	..	..	..	..	50	..	..	..	..	..
513-02848	7-31-50	..	..	38	..	..	..	..	..	..	..
513-02483	7-19-50	..	..	..	..	52	..	..	..	..	..
49-321483	7-5-50	..	..	..	..	..	63	..	..	..	..
513-02853	8-1-50	..	..	38	..	..	..	..	..	..	..
513-02555	8-14-50	..	..	39	..	..	..	..	..	..	..
513-02664	8-30-50	..	29	..	..	..	..	..	..	..	..
513-02476	7-17-50	..	..	..	..	..	65	..	..	..	..

ANALYSIS OF DATA

As information from wild doves was not sufficient for age analysis, data from the two sources were combined by statistical procedures. Straight line curves were plotted for penned and wild birds by the method of least squares and the data were subjected to the "t" test (Snedecor, 1948, p. 82). This showed that the chances were 99 to 1 that no significant difference existed between the rate of molt once it began, but the age at which doves of the two groups began molting was significantly different. Penned birds began molting an average of 17 days later than those in the wild. In view of this, 17 days were subtracted from the beginning date of molt of the penned birds, and the data were pooled. A curvilinear regression curve was plotted for the pooled data, and the rate of molt of the juvenal primary wing feathers was calculated (Table 3).

USE OF THE AGE TABLE

The difference demonstrated in the rate of molt of penned and of wild populations lends some sup-

TABLE 3.—RATE OF MOLT OF JUVENAL PRIMARY FEATHERS BASED UPON WILD AND PENNED MOURNING DOVES

	Primary number									
	1	2	3	4	5	6	7	8	9	10
Age (days) when juvenal primary feathers dropped	25	30	37	45	54	66	80	96	117	142
Variance (at one standard deviation level)	±4	±4	±5	±6	±8	±10	±14	±16	±18	±20

port to skepticism in the use of the age table. In calculating the rate of molt and in construction of the ageing table it will be noted, however, that the adjustment was made in the penned rather than in the wild populations. A search through the literature revealed no precise explanation relative to the cause of delayed molt in the penned birds. It has, however, been pointed out by Rowan (1928) that increased activity has a stimulating effect on reproductive organs, and Lesher and Kendeigh (1941) and Höst (1942) demonstrated that molt is tied in closely with reproductive rhythm. It seems possible then that the lack of opportunity for the birds to exercise in their small cages had a retarding effect upon their normal feather development.

Disadvantages in the application of the table to wild populations have become apparent and should be pointed out. Evidently the rate of post-juvenal molt of a bird with any malfunction, disease, or injury is slower than that of the major segment of the population, hence such a bird would be placed in a class younger than its actual age. In the southern portion of the United States it is impossible to use with accuracy the wing feathers as an age criterion for birds killed after October 15. After this date an increasing number of birds have all new wing feathers and in this group it is impossible to tell adults from juveniles. For example, a bird hatched on March 15 will by August 4 (142 days later) have all adult feathers and show no recognizable indications of being a juvenile. Likewise, many adult birds by this date have just completed the post-nuptial molt and have all new primary feathers. Thus, a bird with all new primaries may be either a juvenile or an adult. Frequently a wing will have only one or two old primary feathers remaining; the other eight or nine having been replaced by new ones. These wings are difficult to classify, but in many cases the age class can be determined by feather wear. The tips of feathers of adults that have been used for one year are usually frayed and worn, while those of the juveniles that have been used for only a short period are unworn and smooth.

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A PHEASANT NECK TAG

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The need for a suitable marker to be used on a large number of pheasants released by the Kentucky Department of Fish and Wildlife Resources led to the development of the neck tag described here. The tag was a variation of the game bird marker described by R. D. Taber (1949. A new marker for game birds. Jour. Wildl. Mgt., **13**: 228–231). Tags were used on 7,717 pheasants released from 1950 through 1953 in conjunction with an intensive Pittman-Robertson study of the factors affecting pheasant survival in Kentucky. The writer is indebted to biologists Charles M. Smith and Robert P. Hornsby for much of the data included in this article. All birds were also marked with numbered aluminum leg bands.

The manufacture of the tag (Fig. 1) consisted of pressing two strips of Koroseal, $4\frac{1}{2}'' \times \frac{3}{4}''$, between two sheets of paper with an iron thermostatically set at approximately 250°F. One end of the Koroseal was then inserted through a rustproof No. 1 safety

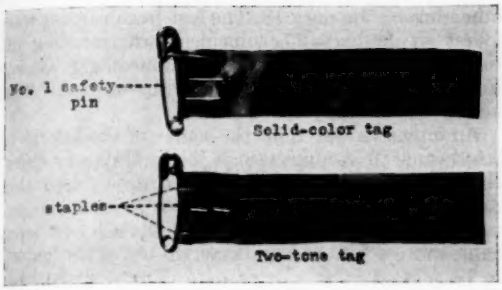

FIG. 1. Pheasant neck tags. Photograph by Jack Rensel.

pin, folded back one inch and pressed together. The fold was reinforced by staples which also aided in securing the safety pin to the rest of the tag. The double thickness of the Koroseal rendered the tag quite durable. Two-tone combinations were obtained by pressing two pieces of Koroseal, $1\frac{3}{4}'' \times \frac{3}{4}''$, to two fused pieces of a different color, $3\frac{1}{2}'' \times \frac{3}{4}''$, overlapping $\frac{3}{4}''$. The completed tag was $3\frac{1}{2}''$ long and $\frac{3}{4}''$ wide.

The tag was attached to the bird by inserting the safety pin through a pinch of skin at the base of the back of the neck. Various colors of Koroseal were used. Solid-color and two-tone combinations served to distinguish birds released at different release sites. With the exception of the tags used on 959 birds in 1950, each of the tags was stamped with a number corresponding to the number on the metal leg band. A waterproof, weatherproof black ink was used.

The tags proved valuable in the identification of dead birds found during the mortality study which followed the release. Of the 7,717 pheasants (7,595 juveniles, 122 adults) released over a four-year period, 2,109 were found dead. Both the band and tag were found in 885 cases, the tag only in 692 cases, and the band only in 157 cases. Neither the band nor tag were recovered in 375 cases. Of the total mortalities recovered, 1,042 or 49 per cent of the bands were recovered, while 1,577 or 75 per cent of the neck tags were retrieved. Through the recovery of bands and tags from pheasants released in 1951 through 1953, 1,624 mortalities or 85 per cent were identified. Since data on individual birds, such as sex and age, were kept, the identification of dead birds played an important role in the mortality study. The neck tags also assisted in determining the mortality rate of the various releases, which were made in a diversity of cover types. The tags also proved helpful in spotting mortalities in cases where the carcasses blended with the soil and ground cover.

The identification of neck tags in field observations supplied data on the dispersal of the pheasants from the release sites. However, difficulty was experienced in identifying the tag on a flying bird. Over a 42-month-period, during which time 3,592 pheasant observations were made, tags were identified in 1,337 observations, or 37 per cent. Tags were observed in 318 additional observations, but the color combinations were not identified. The observations were made under a variety of conditions and circumstances.

Data from field observations revealed a sharp decrease in the number of tags observed as the time from the release dates increased. However, it was believed that these data were misleading, since 97 per cent of the birds trapped from one to seven months after release were found to have retained the tags. Rather, it was assumed that as the adult plumage was attained the tags were less likely to be seen in field observations. The longest period a tag was known to have been retained was 392 days.

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OUTBREAK OF ASPERGILLOSIS IN MALLARDS

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An occurrence of aspergillosis in wood ducks was described by F. C. Bellrose, H. C. Hanson, and P. D. Beamer (1945. Jour. Wildl. Mgt., 9: 325–326). Recent re-reading of that note reminded that my experience of slightly later date had never been reported. During the period 1944–49 several weeks of each winter were spent in operating a duck-banding project on the shores of two lakes just east of Boulder, Colorado.

These lakes are the water supply for the Valmont steam plant of the Public Service Company of Colorado. The water passes through steam turbines, and the lakes are so inter-connected as to provide constant circulation. Warmed by the turbines, the waters never freeze more than two or three feet from the shoreline. At times this is the only open water for miles around and ducks from a large area congregate there. Populations vary, but in very bitter weather there have been as many as 50,000 ducks present. There is no natural food in the lakes and the ducks fly out to farm stubble or corn fields to feed.

On January 17, 1949, after having the traps closed for 15 days due to blizzard, the surface and

shoreline of the lakes was found dotted with sick and dead ducks, and the management of the plant much worried over the sudden die-off. At places the shore was completely lined with carcasses, many of them freshly eaten by gulls, crows, hawks, and other predators. On 75 yards of shore line 21 fresh carcasses were collected.

Specimens were immediately taken to the Bureau of Animal Industry pathological laboratory in Denver, where Dr. C. L. Davis diagnosed death by aspergillosis. Returning to the Valmont plant on January 18, all carcasses were thrown back from the shoreline, and all apparently new carcasses were counted. Some were uncertain because of the work of the scavengers. An inaccessible group of carcasses floating at the headgate were also counted. The total count on this date was 893, of which almost all appeared to be freshly dead.

Most of the dying birds were in excellent condition, fat and heavy. Random post mortems were made on more than 100 birds. All had died of aspergillosis. Actions of sick birds on the lakes were very similar to those observed by Bellrose, Hanson and Beamer. Birds in dying condition were still numerous on January 18. The last fresh carcass was found on January 25, coincident with melting of the snow and opening up of normal feeding grounds. Final figures on the losses suffered ran between 1,000 and 1,100, virtually all mallards.

An intensive search for the source of the infection was begun on January 18. A few miles away from the lakes a silo had been opened up to feed the cattle during the blizzard. Over a foot of rotten, moldy ensilage from the surface of the silo had been hauled into a field and scattered on top of the snow, to be plowed in at a later date. The ensilage had contained quite a few well matured ears of corn. Ducks had been observed flying from the Valmont lakes to feed on the ensilage. While all evidence was circumstantial, concensus of opinion was that this epizootic was caused by the ducks feeding on the moldy ensilage during the period of scarcity of food occasioned by heavy snow. With the opening up of normal feeding grounds they did not return to the ensilage, and the epizootic ended as suddenly as it had begun.

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Correction:

The paper by Victor C. Michael and Stephen L. Beckwith which appeared in the April issue of the JOURNAL should have carried a statement indicating that the investigation on which this paper was based was supported largely by the Florida Game and Freshwater Commission as Federal Aid Project W-24-R, and the paper represents the final report on this project.